

The WHAT'S NEW magazine

FEBRUARY 1989

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# Popular science®

Secrets of the  
superglues

America's trucks—  
muscle and  
comfort

# X-31

Radical new technology  
makes it the deadliest,  
most agile fighter ever



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The challenge was to create a new car worthy of wearing the Thunderbird wings. The result is the most aerodynamic Thunderbird ever. And a car with performance to match its looks.

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# New Ford Thunderbird

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## X-31 fighter

As missiles get smarter, fighter pilots will need super-agile planes to jockey into position and launch first. The experimental X-31 fighter will solve that by changing flight dynamics: It will be able to execute lightning-quick "impossible" maneuvers that make other planes stall. **Page 58**



## Don't rock the boat

No more motion sickness? Two novel boat hulls will be able to prevent pitch and roll—one by riding above and one by gliding below the surface turbulence. The hulls are now being fitted to luxury pleasure craft. **Page 74**



## Superglue secrets

Sure they cure fast, but cyanoacrylate glues have been anything but super for many users. Now you don't have to get a weak or failed bond. We tell how to use the stuff that really works. **Page 80**



## America's trucks

Is today's pickup becoming less of a workhorse as makers add modern technology and comforts? We test the mettle of trucks from Chevrolet, Dodge, and Ford. **Page 44**



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COVER ILLUSTRATION  
 BY MARK McCANDLISH



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# Readers Talk Back

## Subjective at best

I just finished December 1988's "Best of What's New" feature and found it interesting. But with all the new Super VHS machines on the market, I can't believe you selected the Panasonic PV-4826 VCR as the best. After all, how many times will it really be necessary to program over the phone? And, secondly, if you've forgotten to program the machine, chances are that you've also forgotten to insert a tape! Let's see them accomplish that telephonically. I think the idea for your "Best of What's New" feature is great, but let's keep readers informed of the best—not the slickest.

Jay Austin, Killeen, Texas

## Spy plane revealed?

As a high-school science teacher, I enjoy reading POPULAR SCIENCE and use it in my classes. However I spotted a mistake in the November article "Revealed! Mach 5 Spy Plane." In it you state that only astronauts have reached altitudes of 100,000 feet or beyond. But a check of *The Guinness Book of World Records* reveals that manned balloons have risen to heights of over 125,000 feet. Your magazine has such a good reputation with my students that I had a hard time convincing them that I was right!

Charles Bezanson, N. Carver, Mass.

The statement that the spy plane travels at Mach 5, or 3,800 mph, at 100,000 feet altitude is inaccurate. At 57.6 degrees F the speed of sound is 760 mph. But the reference book I consulted gives the temperature at 100,000 feet as minus 58 degrees F. That means that Mach 1 would be 683.6 mph and Mach 5 is then 3,418 mph.

William O. Johnston, Bexley, Ohio

*If we knew for sure that the performance of the hypersonic spy plane is Mach 5 at 100,000 feet, then we could immediately infer that the speed is 3,418 mph because the speed of sound at that altitude is 683.6 mph. Likewise, if we knew for sure that the speed indeed was 3,800 mph at 100,000 feet, then we could conclude that the plane is actually Mach 5.75. However the disclosures about the*

*performance of this secret spy plane are limited. The Los Angeles Times reported on Jan. 14, 1988, that "the new stealth reconnaissance aircraft reportedly will be capable of speeds nearing Mach 5, or 3,800 mph, and of flying at an altitude above 100,000 feet." Because temperature begins increasing at altitudes above 85,000 feet, so does the speed of sound—returning to the sea-level value of 60 mph at 58,000 feet. The Times statement suggests that the true spy-plane altitude would be above 100,000 feet. The facts remain elusive because releasing a clear value for sound speed would be equivalent to pinning down the spy plane's operating altitude.—T. A. Heppenheimer*

## No bitter memories

In the November 1988 article "Magnetic Personalities" the author incorrectly states that I could not win support and was hampered in the early days by a magnet installed in the laboratory next to mine at the Francis Bitter National Magnet Laboratory. That incident took place before I came to the Massachusetts Institute of Technology. It took place at the University of Illinois Circle at Chicago Circle, where the administrators and some of my senior colleagues took a dim view of my new ideas of biomagnetism and gave me a bit of a hard time.

In contrast, Dr. Benjamin Lax, then the director of MIT's Francis Bitter National Magnet Lab, rescued me (and biomagnetism) in 1969 and gave me and this young science a new and friendlier home. I believe that we have both thrived since then.

David Cohen

Biomagnetism Group Leader  
Francis Bitter National Magnet Lab.

Massachusetts Institute  
of Technology  
Cambridge, Mass.

## Raining planes

As both a military and a civilian pilot, I feel there are many disadvantages and even safety hazards created by the ballistic-recovery system ["Plane-Saving Parachute," Dec. '88]. The primary problem is that the chronically apprehensive pilot will deploy the chute long before giving recovery a chance. One example is the stall-spin condition, which can be recovered safely with

*Continued*

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# Yamaha Terrapro owners find happiness right in their own backyard.



JOHN: "When we're done mowing the back, we just upshift and run right over to the front yard. Saves a lot of time."  
WANDA: "By the way, I'm the one who does the mowing."

John & Wanda Purcell  
Paducah, Kentucky



"The Terrapro's easy to maneuver and real smooth riding. And after mowing my acre and a half, I can take it down along the creek and have some fun."

Wayne Horstman  
Ownesville, Missouri



"I can maneuver easily around individual fruit trees. Whereas anything larger needs a lot more room. And I can go all day without getting tired."

Mike Durbiano  
Goleta, California

To paraphrase an old saying, "It takes a heap of mowing to make a house a home."

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minimal altitude loss if the pilot applies the proper recovery procedures. Other opportunities for premature deployment include inexperienced pilots attempting night landings or instrument approaches in bad weather. Just imagine what our skies would look like if all general-aviation airplanes were equipped with the BRS. Airplanes floating down out of the sky would be a common sight. And where are they all going to land? Backyards, shopping centers, freeways? I think a pilot should develop the confidence to recover an airplane without resorting to a security blanket. However, if indeed recovery is impossible—the result of a mechanical failure, for example—he has the parachute on his back with which to escape.

1st Lt. Kenneth M. Ferguson  
U.S. Air Force, San Jose, Calif.

## Over-powered smoke pots

Sixty lashes to the Detroit auto manufacturers. In your October 1988 special section, "Detroit Powers into '89," there was no mention of designing a pollution-free car. Instead the jokers in Detroit can think of nothing except over-powered cars that can exceed 150 mph (on 65-mph freeways). Who wants to drive a shoehorn that costs 50,000 bucks and can't carry four people comfortably? We have enough trouble trying to solve the smog problem without adding a few thousand smoke pots to the highways. We need 230-horsepower cars like we need holes in the head!

Fred W. Hunt, Bellingham, Wash.

*All cars mentioned in the special section meet or exceed all emissions regulations.*

## Toolbox tales

A look at the item Nicer to Knuckles ["What's New Tools," Nov. '88] had me digging into my tool box for something I've been using for many years—my Adjust-A-Box. It may not be as shiny and smooth as the new Pocket Socket but it seems to do all the same jobs. It's even been used as a hammer in moments of poor discretion—no chrome, no problem! Hopefully the patent has run out on the original and we'll see this handy and useful tool around again.

Andrew Lancashire, West Chester, Pa.

*The Adjust-A-Box tool has not been made for many years, probably due to certain strength deficiencies that the Pocket Socket wrench is designed to correct. The movable jaw of the older de-*

*sign extends from the wrench body and is prone to break off or deform when used fully extended (on larger nuts). The movable jaw of the Pocket Socket is fully enclosed and supported within the body of the wrench itself at all times. In fact, the more its movable jaw is opened, the farther it is drawn into the stronger center area of the body, where leverage stresses are less.—Ronald A. Kramer, president, Worthington Technologies, Worthington, Ohio*

## Stoplight scanner

When I read the November 1988 article "Stoplight Sentry," I thought of an idea I got years ago: a scanner that would monitor an intersection and change a red light to green when there is no traffic coming the other way. I realize that a traffic light ensures safety at an intersection, but it seems like a waste of time and fuel to stop a car when no other vehicle is around.

Donn B. Henley, Pine Hill, N.J.

## Planning ahead

In the spring of 1937 POPULAR SCIENCE published plans for the *Malek Adhel*, a detailed model brig—realistic from the keel to the ribs to the individual planks. The plans were the work of Capt. E. Armitage McCann. I was 16 years old then and had neither the tools nor the required skills to build the brig, but I collected the plans each month and saved them for when I had grown old and retired. Fifty years later, on Jan. 5, 1988, I laid the brig's keel. I estimate it should take another year to complete deck fittings, masts, spars, and the rigging. Have any other readers of my vintage built the *Malek Adhel*? Congratulations to POPULAR SCIENCE on more than a century of publishing a fine magazine.

Leonard G. Doran, Carlisle, Pa.

## Dec-Klips source

I held off building a 340-foot outdoor deck in order to use Dec-Klips ["Two Stepped Decks," Aug. '88] for the project. I can't seem to locate the source of the product.

Hugh Cahill, Maplewood, N.J.

*The new address for the Dec-Klips source is: Hermitage Building Supplies, Box 1000, Vancouver, B.C. V6B 2J5.*

**Correction:** On page 69 of the October 1988 issue the photo on the upper left was incorrectly credited. It should have read: Howard B. Bluestein, University of Oklahoma. **P S**

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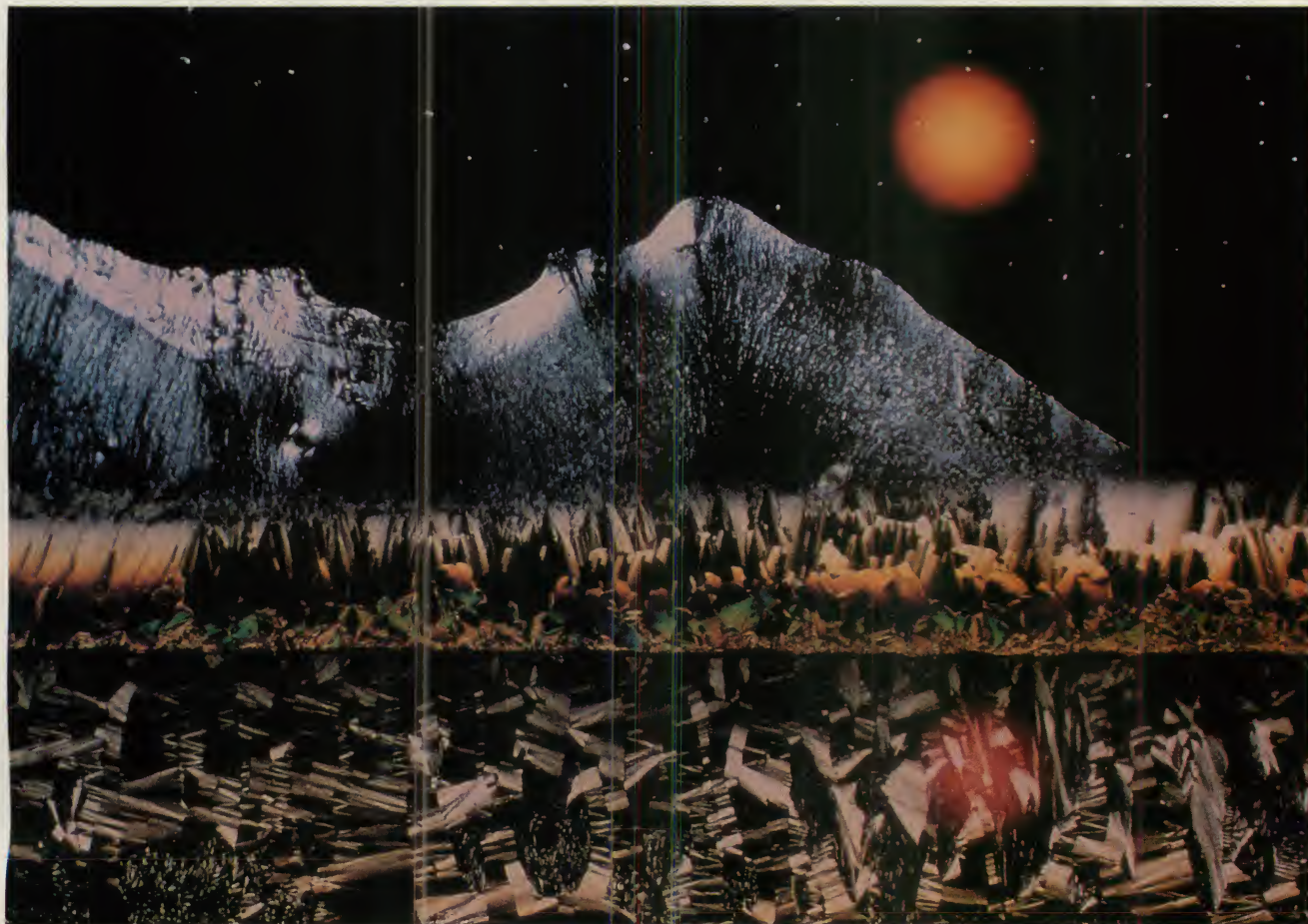
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# Science Newsfront

By ARTHUR FISHER



"This competitor very much deserved winning the grand prize," said one judge of this Polaroid picture.

## Fantastic landscape

Can you guess what this is a picture of and how it was made? Hint: It's not the product of a Hollywood special-effects lab, nor is it one of those remarkable computer-generated graphics that uses fractal mountains.

Answer: It's a photomicrograph called "Liquid Crystal Land," and it was made by superimposing five exposures of different organic chemical solutions, using a variety of filtering, masking, and imaging techniques. The magnifications used ranged from 10× to 25×.

The photo won both the first and grand prizes in the 1988 Polaroid International Instant Photomicrography competition for its maker, Dr. Michael W. Davidson, a research associate at Florida State University's Institute of Molecular Biophysics. It is the crowning glory of an avocation launched a couple of years ago when Davidson

noticed how a slowly evaporating solution on a microscope cover glass resembled reeds at the edge of a lake.

## Fastest supercomputer

What NASA experts state is the world's fastest supercomputer, the Cray Y-MP, has been installed at the Numerical Aerodynamic Simulation Facility (NAS) of the space agency's Ames Research Center in Mountain View, Calif. The device can exceed one billion computations per second in sustained operation. It has achieved a peak speed of 2.37 billion computations per second by concentrating all its processors on a single scientific simulation. The Cray-2, which was the record holder when it was installed in 1985 at NAS, has a speed of 250 million operations per second.

The new Cray computer has eight processors, 32 million words of main memory, and 256 million words of sec-

ondary semiconductor memory in the form of a solid-state storage device. It achieves its great speed by combining three key features: very fast processors, fast memory access, and parallel-processing capability. The last element means that all eight of the high-speed processors can attack a single problem. Their speed, in turn, depends on densely packed components to minimize the distances over which electronic signals travel at close to the speed of light.

Like previous supercomputers at NAS, the Cray Y-MP will be used to simulate the behavior of advanced airplanes and spacecraft, complementing wind-tunnel and shock-tunnel testing.

With the Cray Y-MP, NAS will model complete vehicle configurations and will move toward reproducing the airflows encountered in such difficult cases as the flight of helicopters, powered-lift and tilt-rotor vehicles, and supersonic fighters in high-maneuverabil-

*Continued*



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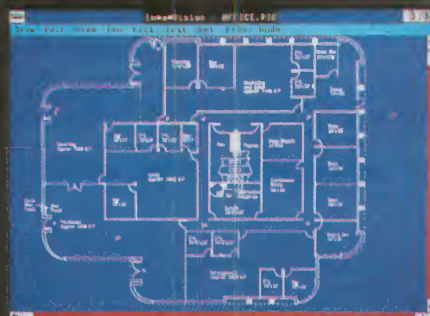




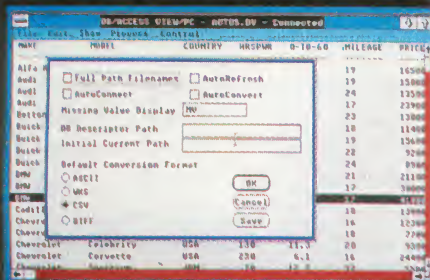
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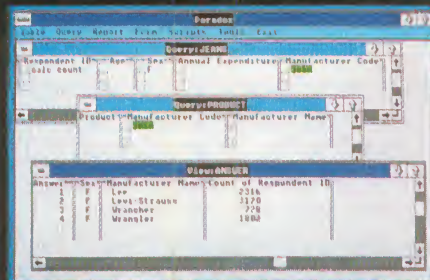
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ity, very high-angle-of-attack positions.

Eventually, NASA officials hope to gain computation speeds of one trillion calculations per second. That level would revolutionize aerospace science by allowing designers to reproduce a series of optimum designs quickly for a given flight problem.

## Moon kit

The Astronomical Society of the Pacific has released a new set of slides and information on the moon, including close-ups of dramatic features and shots from the Apollo 11 landing. The slides are accompanied by a 24-page booklet that offers, beyond detailed background information, tables of all the lunar missions and a chart for telling time by the moon. The material announcing this release says the kit is ideal for "teachers, students, vampires..." but I think they mean werewolves.

If you qualify, send \$24.45 to A.S.P., Moon Kit Dept. NPK, 390 Ashton Ave., San Francisco, Calif. 94112. Outside of the United States, add \$3 for additional postage.

## Bar code for bees

Glued to this honeybee's thorax is what has got to be the world's smallest bar code—one that is machine readable with a laser scanner. Purpose: to allow apilologists to tag, collect, and identify bees over their range, which is typically from two to four miles. Such knowledge is vital to the continued success of crop-pollination programs. Honeybees pollinate a wide variety of food and other crops; experts estimate that the total bee contribution to American agriculture, direct and indirect, is \$20 billion.

Developer of the novel bee-tagging system is Dr. Stephen L. Buchmann, an Agricultural Research Service entomologist at the Carl Hayden Bee Research Center in Tucson, Ariz. He was seeking a substitute for conventional tagging methods, which consisted of applying dots of quick-drying model-airplane paint, or even writing numerals in permanent ink on a white background. Such methods were time-consuming, requiring human intervention to decode the labels—and the identifications tend to wear off quickly in the field. What was needed was a label that was machine readable. When Buchmann learned that a company called

Intermec had developed a special ultra-high-density bar code, he asked company scientists to help with his mission. The result is the label in the photo. Only two millimeters wide, the label can code any two-digit number.

The rest, as they say, is bzzstory.

## California wind

A monster order for giant wind turbines has been placed with Mitsubishi Heavy Industries, Ltd., for delivery to Tehachapi, Calif. There the 340 machines, each with a power output of 250 kilowatts, will be installed in a wind farm. The MWT-250 turbines have three 28-meter-long fiber-reinforced



When this honeybee is captured from the wild, a laser scanner will read the information coded on its back in the world's smallest bar code.

plastic blades mounted on a 30-meter-high tower. They have both a blade-pitch control system (to change the blade angle with wind speed) and a yaw control system (to align the turbine with the wind direction).

The wind farm is a joint venture of Toyo West, a Japanese company, and Sea West Industries of San Diego. The electricity generated will be sold to Southern California Edison Co.

## Bag conquers Everest

A sleeping bag invented by a chemical-engineering professor at the University of Colorado at Boulder has saved the lives of at least two climbers on Mount Everest and may become

standard equipment for future high-altitude mountaineers.

The bag was designed by Igor Gamow to cope with the onset of altitude sickness—the bane of climbers who dare high altitudes, where pressure is low and oxygen is scarce. The disease causes pulmonary and/or cerebral edema—lungs and brain fill with fluid. It can be fatal, and the only treatment is to descend to lower altitudes, often difficult or impossible in adverse weather conditions.

Gamow's invention, a modified sleeping bag, simulates the air pressure of a lower altitude when it is inflated by a foot pump. At an altitude of 14,000 feet, it provides air pressure equivalent to an altitude of 7,800 feet. At Everest's crest, the bag would reduce the effect of the altitude by 9,000 feet.

Gamow says that two trekkers on the Nepalese side of Everest, one of them comatose, were saved by the bag at the 14,000-foot-high Himalayan Rescue Association's medical clinic. And last fall, 6 of 31 members of a Wyoming expedition to Everest were also helped by the bag. When a patient is inside the bag he feels as if he were under 4½ feet of water. The sensation is not uncomfortable, says Gamow.

## Rare mineral on Mars

Planetologists have long puzzled over how the mostly carbon dioxide atmosphere of Mars is maintained. The gas lost to space must somehow be replenished, suggesting a reservoir of some sort in the soil or the polar caps. Until now, no likely source has been found.

In November 1988 scientists of the U.S. Geological Survey and the University of Arizona announced they had learned the answer. It is a mineral called scapolite, relatively rare on Earth but apparently abundant on the Martian surface. It is the right candidate, they explained, because it can store large quantities of carbon dioxide as carbonate in its crystal structure.

On Earth scapolite is a semiprecious gem mineral with a range of amber colors. Its constituents include the elements sodium, calcium, potassium, aluminum, silicon, chlorine, carbon, sulfur, hydrogen, and oxygen. Future explorers of Mars are not likely to pick up any scapolite gemstones, however; the mineral grains detected till now are far too small. The scientists said

*Continued*



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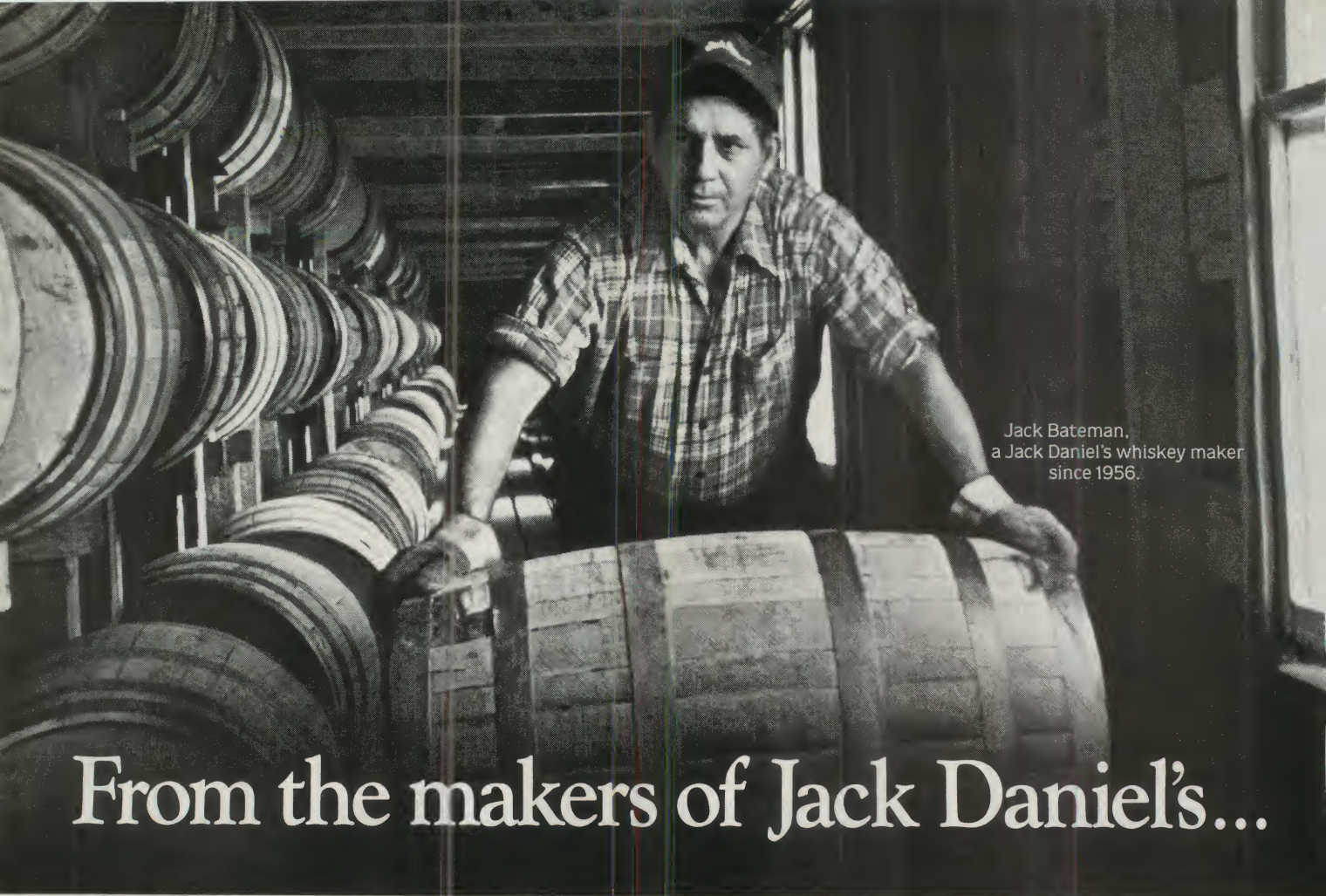
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# From the makers of Jack Daniel's...

## Science Newsfront *Continued*

that scapolite is probably a component of the dust that covers the planet, and it seems to be universally distributed.

The discovery was made by Roger N. Clark and Gregg A. Swayze of the USGS in Denver, and Robert B. Singer of the University of Arizona in Tucson. In August and September 1988, during Earth's closest approach to Mars in almost 20 years, they used a new spectrometer on NASA's three-meter telescope atop Mauna Kea in Hawaii to study the near-infrared spectrum of light from many regions of the planet. They found five bands of light absorption matching those of scapolite, positive identification.

### Missing crust found

Mars is different from Earth in still another significant way. Its crust makes up at least 10 percent of the planet's mass. That same ratio applies to the moon. Yet Earth's crust constitutes **no more than four-tenths** of one percent of terrestrial mass. Ever since unmanned spacecraft visited the moon and Mars and divined their crustal proportions, geophysicists have been

perplexed by the discrepancy. What happened to Earth's missing crust?

The answer, says Don L. Anderson, director of Caltech's Seismological Laboratory and a professor of geophysics there, is that much of Earth's crust has sunk into the middle mantle to a depth of 400 to 650 kilometers beneath the surface. "We have recently developed a technique that allows us to obtain information on the chemical composition of Earth's mantle," Anderson reported last fall to the annual meeting of the Geological Society of America in Denver. "This technique has revealed that there is a great deal of crustal material in the middle mantle... [which] appears to be a dumping ground for the huge slabs of crust that dive into Earth's interior at subduction zones such as the 'ring of fire' around the Pacific."

The technique uses slight variations in the travel times of seismic waves generated by earthquakes ["Voyage to the Center of the Earth," Nov. '88]. It shows that the middle mantle consists largely of calcium-rich majorite, exactly what crustal material would be if it were squeezed at the extreme pres-

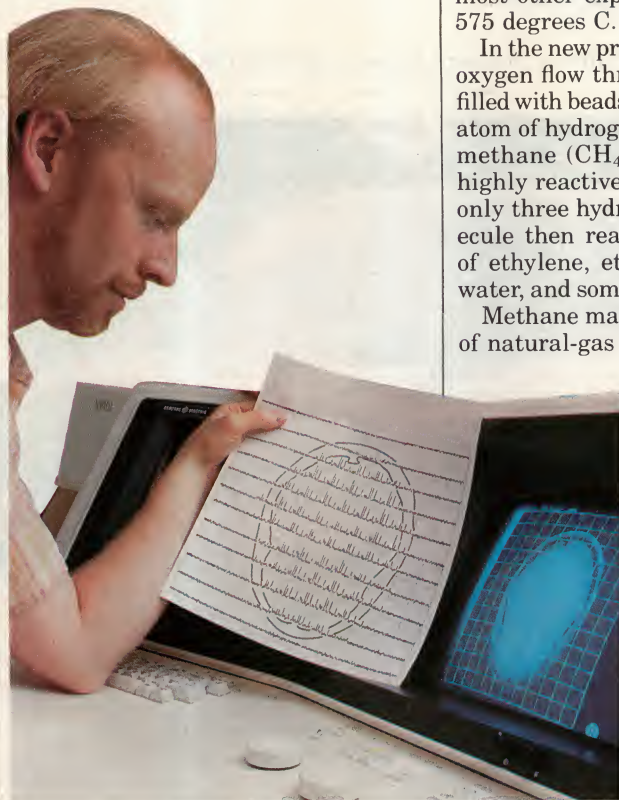
ures below 400 kilometers deep. There is so much of it that if it were all brought to the surface, the crust would be 200 kilometers thick instead of 20.

### Ethylene from methane

Ethylene is a colorless gas given off by ripening fruit. The hydrocarbon ( $C_2H_4$ ) is also the basic raw material of today's multibillion-dollar petrochemical industry. It is used to make thousands of petrochemical and related products: ethylene glycol (antifreeze), ethyl alcohol (used in solvents, flavorings, cosmetics, and detergents), resins, polymers, and polyvinyl chloride and polyethylene—the basic building blocks of most modern plastics. It is made from petroleum at the refinery.

Now two chemical engineers at the University of Michigan have developed a catalytic process that makes ethylene from methane, an inexpensive and relatively abundant gas. Eran Gulari, an *associate dean at the College of Engineering*, and Ananth Annapragada, a graduate student, succeeded in using an iron phosphate catalyst to convert methane to ethylene at a temperature





several hundred degrees lower than most other experimental processes—575 degrees C.

In the new process, methane gas and oxygen flow through a heated reactor filled with beads of iron phosphate. One atom of hydrogen is stripped from the methane ( $\text{CH}_4$ ) molecule, leaving a highly reactive form of methane with only three hydrogen atoms. This molecule then reacts to form a mixture of ethylene, ethane, carbon dioxide, water, and some higher hydrocarbons.

Methane makes up 20 to 80 percent of natural-gas deposits, an attractive

**Magnetic-resonance spectroscopic images may help solve medical mysteries.**

figure when compared with dwindling petroleum reserves.

## MRI scanner

The first-ever spectroscopic images of the brain made with a four-tesla magnetic field appear in this photo. The images consist of an array of spectra that map the amounts and locations of key chemicals—metabolites—involved in fueling cellular functions. The spectra have been generated with an experimental magnetic-resonance scanner at General Electric's Research and Development Center in Schenectady, N.Y. ["Magnetic Personalities," Nov. '88]. The system is based on a 50-ton superconducting magnet capable of producing a uniform magnetic field of four tesla—about 80,000 times the intensity of Earth's field. That is more than twice as powerful as the commercial units now in use in hospitals around the world.

The areas of the brain to which the spectra relate are shown in the magnetic-resonance image at left. "Right now we are doing exploratory research employing an experimental machine," says Dr. Rowland W. Redington, a GE researcher.

PS

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# Automotive Newsfront

By **DAN McCOSH** Detroit Editor with Timothy O. Bakke, Stuart Brown, Richard Stepler, and Brian Nadel



Buick's Park Avenue Essence concept car shows trends for models the GM division will introduce in the 1990s.

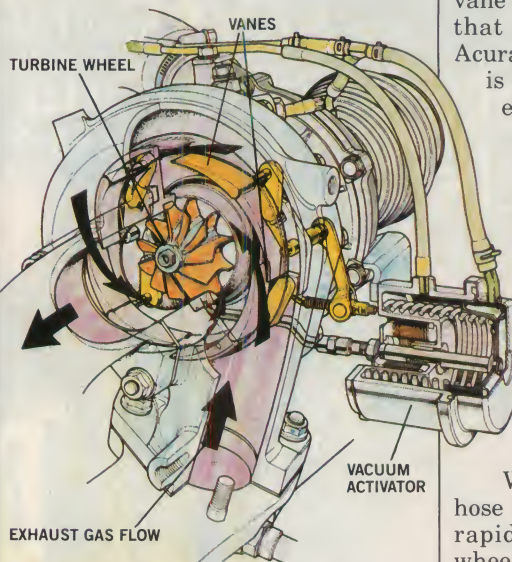
## Buick's Essence

This is a test. Does the car pictured above conjure up words like distinctive, substantial, powerful, and mature to you? If it does, then Buick's Park Avenue Essence concept car successfully projects the image with which Buick plans to distinguish itself from the other divisions of General Motors.

The car is certainly substantial in size and appointments. At 210 inches overall length on a 113.8-inch wheelbase, the four-door sedan accommodates six passengers in three-abreast seating. A new hinge design allows the doors to open extra wide for easier access, and power footrests front and rear adjust for comfort. The sweeping windshield (raked at 65.5 degrees) and instrument panel are far forward, enhancing the cabin's spaciousness. Climate and entertainment systems are individualized: The driver and three passengers can select their own temperature and fan settings. Three passenger headphones use infrared sound transmission for cordless operation ["No Strings Attached," July '88].

The sleek body (coefficient of drag is estimated at less than 0.30) rides on large 225/60R16 wheels and tires. Power comes from GM's 3800 V6 engine with redesigned heads, manifold,

and fuel injection, and rated at 185 horsepower at 4,400 rpm. Buick says the car accelerates from 0 to 60 mph in about nine seconds. You can get a look at the Park Avenue Essence at selected 1989 auto shows.



Honda's variable-vane turbo rings the turbine with four controllable vanes that close at low speeds and open at high speeds. The vanes act like flaps, redirecting the exhaust gas flow against the wheel.

## Variable progress

No-lag turbochargers are coming on strong. Honda appears to have scored a slight edge over Chrysler by introducing the first production variable-vane turbocharger on a two-liter V6 that powers the latest-generation Acura Legend in Japan. Chrysler still is expected to be first in the United States, however, with a variable-vane turbo on a 2.2-liter four-cylinder engine in a Shelby-prepared Shadow CSX coupe. The Shelby Motorsports conversion shop will fit the Shadow with a Garrett-produced variable-vane turbo to be introduced later this spring.

The new generation of turbochargers uses a series of vanes or flaps that control the velocity of exhaust gas directed at the turbine wheel [May '88]. Working something like a garden-hose nozzle, the new systems allow a rapid acceleration of the turbine wheel when the driver steps on the gas pedal, supposedly eliminating so-called **turbo lag**.

Early versions of the system consisted of a ring of vanes to control the exhaust gas stream, but production versions are expected to have a single

*Continued*



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**Itzhak Perlman: French Violin Showpieces** • Carmen Fantasy, Tzigane, Poème, Havanaise, more. DG DIGITAL 115457

**Tracy Chapman** • Extraordinary singer/songwriter with hit *Fast Car*, *Talkin' Bout A Revolution*, *Baby Can I Hold You*, *Mountains O' Things*, *Why?*, etc. Elektra 153582

**Guns N' Roses: Appetite For Destruction** Welcome To The Jungle, Sweet Child O' Mine, It's So Easy, more. Geffen 170348

**Jerry Lee Lewis: Original Sun Greatest Hits** • Whole Lotta Shakin' Goin On, Great Balls Of Fire, more. Rhino 154118

**Kitaro: The Light Of The Spirit** • Sundance, Mysterious Encounter, The Field, In The Beginning, etc. Geffen DIGITAL 164228

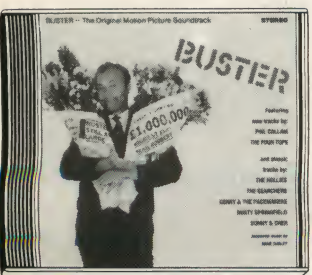
**Richard Marx** • Endless Summer Nights, Should've Known Better, Don't Mean Nothing, etc. EMI-Manhattan 134073

**Jimmy Page: Outrider** • Wasting My Time, The Only One, Prison Blues, more. Geffen 123721

**Robert Plant: Now And Zen** • Dance On My Own, Heaven Knows, Tall Cool One, Ship Of Fools, etc. Es Paranza 134392

**Led Zeppelin: Houses Of The Holy** Dyer Maker, Over The Hills And Far Away, etc. Atlantic 134321

**George Harrison: Cloud Nine** • Title song, I Got My Mind Set On You, When We Was Fab, more. Warner/Dark Horse 174328



**Phil Collins: Buster** 100517

**James Taylor's Greatest Hits** Warner Bros. 123790

**Dire Straits: Brothers In Arms** • Money For Nothing, Walk Of Life, So Far Away, more. Warner Bros. DIGITAL 114734

**Pops In Space** • John Williams & The Boston Pops. Music from Close Encounters, Star Wars, others. Philips DIGITAL 105392

**Rod Stewart: Greatest Hits** • Do Ya Think I'm Sexy?, Tonight's The Night, Maggie May, Hot Legs, etc. Warner Bros. 133779

**Andrés Segovia Plays Bach** • Includes the famous Chaconne. MCA 163600

**Poison: Open Up And Say...Ahh** • 'Nothin' But A Good Time, Good Love, Fallen Angel, Love On The Rocks, etc. Capitol/Enigma 173989

**Bobby McFerrin: Simple Pleasures** Don't Worry Be Happy, All I Want, Drive My Car, title song, Good Lovin', more. EMI-Manhattan 164165

**Cream: Disraeli Gears** • Sunshine Of Your Love, more. Polydor 104898

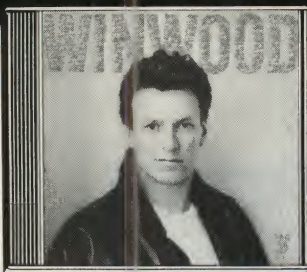
**Simon & Garfunkel: The Concert In Central Park** • Mrs. Robinson, Bridge Over Troubled Water, etc. Warner Bros. 244006

**Alabama: Live** RCA 160027

**Previn: Gershwin** • Rhapsody In Blue, Concerto In F, more. Philips DIGITAL 115437

**Eagles Greatest Hits, Vol. 1** Asylum 123481

**Keith Richards: Talk Is Cheap** • Big Enough, How I Wish, Take It So Hard, Struggle, I Could Have Stood You Up, more. Virgin 100518



**Steve Winwood: Roll With It** 154633

**Liz Story: Speechless** • Forgiveness, Speechless, Welcome Home, Back Porch, Vigil, Frog Park, more. RCA/Novus 100494

**Decade/Best Of Steely Dan** MCA 154135  
**Beethoven, Symphony No. 7: Coriolan & Prometheus Overtures** • Royal Philharmonic/Previn. RCA DIGITAL 153621

**Jethro Tull: Aqualung** Chrysalis 124705

**Whitney Houston: Whitney** • I Wanna Dance With Somebody (Who Loves Me), Didn't We Almost Have It All, more. Arista 152854

**Metallica: ...And Justice For All** • One, Blackened, title song, To Live Is To Die, Shortest Straw, more. Elektra 200478

**Talking Heads: Naked** • (Nothing But) Flowers, Mr. Jones, Totally Nude, Blind, The Democratic Circus, The Facts Of Life, etc. Fly/Sire DIGITAL 153810

**David Sanborn: Close-Up** • Lush jazz sax effort! Siam, You Are Everything, J.T., Goodbye, Same Girl, etc. Warner Bros. 134408

**Dwight Yoakam: Buenas Noches From A Lonely Room** • Title Song, Streets Of Bakersfield (with Buck Owens), more. Reprise 100009

**The Best Of The Band** Capitol 134485

**Classic Old & Gold, Vol. 1** • 20 hits! A Little Bit Of Soul, He's So Fine, A Teenager In Love, Sweet Talkin' Guy, etc. Laurie 134627

**INXS: Kick** • Need You Tonight, Devil Inside, New Sensation, title song, Never Tear Us Apart, The Loved One, Wild Life, etc. Atlantic DIGITAL 153606

**The Glenn Miller Orchestra: In The Digital Mood** • In The Mood, Chattanooga Choo Choo, more. GRP DIGITAL 143293

**Tangerine Dream: Phaedra** 100510

**Steve Winwood: Chronicles** • Higher Love, Valerie, While You See A Chance, My Love's Leavin', Talking Back To The Night, more. Island 134501

**Pictures At An Exhibition, Night On The Bare Mountain, more** • Montreal Symphony/Dutoit. London DIGITAL 125314

**Whitesnake** • Here I Go Again, Still Of The Night, Give Me All Your Love, Crying In The Rain, Bad Boys, more. Geffen 163629

**ZZ Top: Afterburner** Warner Bros. 164042

**Carly Simon: Greatest Hits Live** Anticipation, You're So Vain, Coming Around Again, Nobody Does It Better, etc. Arista 154537

**Huey Lewis: Small World** • Perfect World, Walking With The Kid, World To Me, Better Be True, Old Antonio's, etc. Chrysalis 134347



**Horowitz Plays Mozart** 115436

**Najee: Day By Day** • Personality, title song, That's The Way Of The World, Tonight I'm Yours, Gina, Najee's Nasty Groove, etc. EMI-Manhattan 100001

**Genesis: Invisible Touch** • Land Of Confusion, title song, etc. Atlantic 153740

**More Dirty Dancing** • Do You Love Me, Love Man, Big Girls Don't Cry, Wipeout, Some Kind Of Wonderful, Cry To Me, more. RCA 130766

**The Who's Greatest Hits** MCA 164160

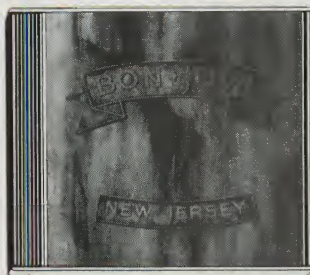
**Tchaikovsky, 1812 Overture; Romeo & Juliet; Nutcracker Suite** • Chicago Symphony/Solti. London DIGITAL 125179

**James Galway: Greatest Hits** RCA 173233

**The Moody Blues: Sur La Mer** • I Know You're Out There Somewhere, No More Lies, Here Comes The Weekend, Vintage Wine, etc. Polydor 124546

**The Beach Boys: Endless Summer** California Girls, Help Me Rhonda, Surfer Girl, more. Capitol 223559

**Cinderella: Long Cold Winter** • Gypsy Road, Don't Know What You Got (Till It's Gone), The Last Mile, etc. Mercury 114780



**Bon Jovi: New Jersey** 100516

**Strauss, Also sprach Zarathustra** Chicago Symphony Orchestra/Reiner. RCA 163627

**Charlie Parker & Dizzy Gillespie: Bird & Diz** • Leap Frog, My Melancholy Baby, Mohawk, etc. Verve 173413

**Robert Palmer: Heavy Nova** • Simply Irresistible, Disturbing Behavior, She Makes My Day, More Than Ever, Change His Ways, etc. EMI-Manhattan 100035

**The Very Best Of The Everly Brothers** Bye Bye Love, Crying In The Rain, Bird Dog, others. Warner Bros. 130826

**Kenny G: Silhouette** • We've Saved The Best For Last, title song, Tradewinds, Pastel, Against Doctor's Orders, Let Go, more. Arista 100603

**D.J. Jazzy Jeff & The Fresh Prince: He's The D.J., I'm The Rapper** • Parents Just Don't Understand, Nightmare On My Street, etc. Jive 264134

**Raffi: Singable Songs For The Very Young** Shoreline 144494

**Elton John: Reg Strikes Back** • A Word In Spanish, I Don't Wanna Go On With You Like That, Goodbye Marlon Brando, Town Of Plenty, etc. MCA DIGITAL 100602

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**Vivaldi, The Four Seasons** • English Concert/Pinnock. Archiv DIGITAL 115356

**Joe Cocker: Classics** Contains 13 Hits! A&M 104887

**Bruce Hornsby And The Range: Scenes From The Southside** • The Valley Road and Jacob's Ladder, plus others. RCA 180187

**Crosby, Stills, Nash & Young: Greatest Hits (So Far)** • Suite: Judy Blue Eyes, etc. Atlantic 130230

**New Age Bach: The Goldberg Variations** Joel Spiegelman plays the Kurzweil 250 Digital Keyboard. East-West 100488

**John Cougar Mellencamp: The Lonesome Jubilee** • Paper In Fire, Check It Out, Cherry Bomb, Rooty Toot Toot, etc. Mercury 134420

**Elvis: 18 Number One Hits** RCA 172190

**Robert Cray: Don't Be Afraid Of The Dark** Title song, Don't You Even Care, more. Mercury/Hightone 100471

**Jimi Hendrix: Kiss The Sky** • Purple Haze, All Along The Watchtower, Voodoo Child, Are You Experienced, etc. Reprise 161349

**Parton/Ronstadt/Harris: Trio** • To Know Him Is To Love Him, etc. Warner Bros. 114804

**Chicago 19** • I Don't Wanna Live Without Your Love, Heart In Pieces, etc. Reprise 154404

**Peter Cetera: One More Story** • One Good Woman, more. Warner Bros. 100463

**Buckwheat Zydeco: Taking It Home** Why Does Love Got To Be So Sad? (with Eric Clapton), Creole Country, more. Island 100597

**The Sound Of Music/Orig. Soundtrack** RCA 100046



**Randy Travis: Old 8x10** 100008

**The Police: Every Breath You Take-The Singles** • Don't Stand So Close To Me ('86), Roxanne, etc. A&M 173924

**Sting: Nothing Like The Sun** • We'll Be Together, They Dance Alone, Be Still My Beating Heart, more. A&M 273965

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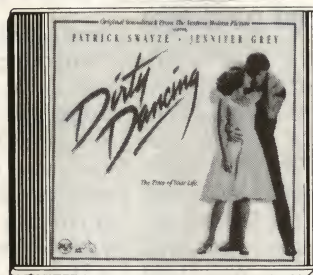
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YAT43 (BU)



flap on one side of the turbine wheel—a simpler design that engineers say is just as effective.

Honda's system rings the turbine wheel with four vanes, which are opened and closed by a vacuum-assisted controller. It is a middle-of-the-road approach that apparently is different enough for Honda to apply for 250 patents on its system. The company hasn't hinted whether it will export a turbocharged car to the United States.

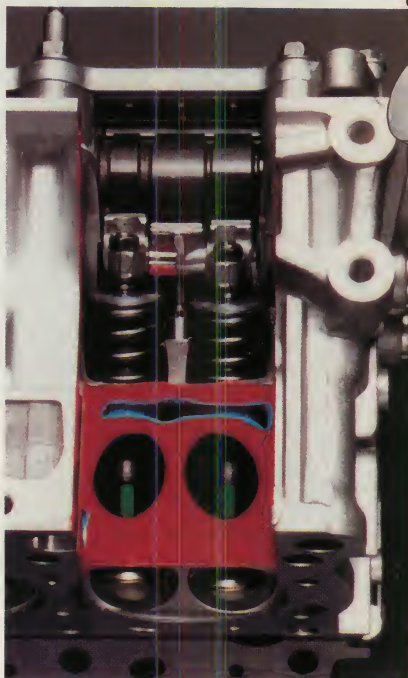
## Variable valves

Controlling valve timing is one route to smoothing out the top-heavy power curve of multivalve engines. Despite numerous devices that have been proposed, a successful variable-valve timing system has proved elusive.

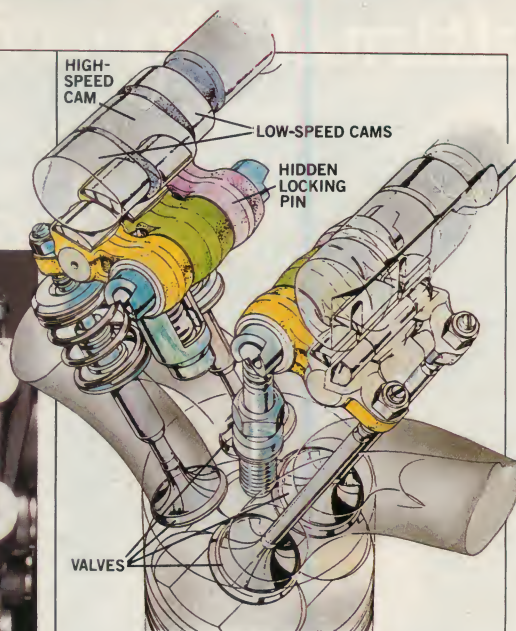
Now Honda says it has a practical answer that has been tested in a 1.6-liter engine, which raises output from 130 to 160 hp without affecting drivability.

The Honda mechanism uses a pair of cam lobes, whose profile corresponds to low engine speeds, separated by a third cam in the center, which has a high-speed profile. A locking pin that is actuated by an electric solenoid is disengaged in the low-speed position, allowing the cam followers to trace the outside lobes. On command, the pin is horizontally inserted to gang all three cam followers together, and the center profile comes into play.

Three cam lobes operate two valves in Honda's valve timing system. The inner lobe overrides the outer two at high engine speeds, when the three are ganged by a locking pin.



The variable-valve timing is controlled by an engine computer that can call on the two valve alternatives when necessary.



piston strokes that permit it to inhale large amounts of the air-fuel mixture at high rpm, while keeping piston speed low enough to prevent the whole thing from blowing up. Despite the engine's free-revving nature, Honda claims it develops useful power over a broad rpm range. It should be noted that the larger reciprocating parts in auto engines endure more stress at high engine speeds than do their miniaturized counterparts on motorcycles, making this sort of reliable performance unrealistic for automobiles.

## Powerful pint-sized package

Perhaps you've already grabbed a calculator and figured out that the Yamaha-built V6 engine on the Ford SHO Taurus boasts a specific power output of over 73 hp per liter, or that Oldsmobile's high-output version of the Quad 4 engine produces a scorching 80 hp per liter. Well, hold onto your camshaft. The 400-cc engine that propels Honda's new CB-1 motorcycle cranks out 57 hp, which on a per-liter basis comes out to a whopping 142.5 hp.

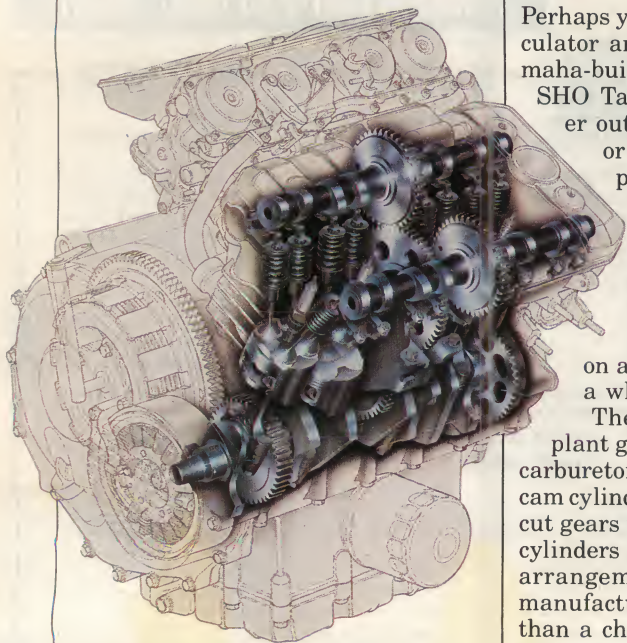
The tiny four-cylinder power plant gets its fuel from a quartet of carburetors feeding a 16-valve twin-cam cylinder head. A train of straight-cut gears running between the center cylinders drives the camshafts. This arrangement is more expensive to manufacture and somewhat noisier than a chain-driven camshaft, but it gives precise control of valve timing, all the way to the engine's 10,500-rpm peak.

The engine takes advantage of short

## Power sport sedan

Rolls-Royce motorcar. Sport sedan. Contradictory images? You may think so—until you see and experience the Bentley Turbo R. This oxymoron-named car from Rolls-Royce Motor Cars is a 5,270-pound behemoth that accelerates from a standing stop to 60 mph in a claimed 6.7 seconds; takes fast, tight corners with the aplomb of a Porsche 911; and yet couches you in the leathery luxury and smooth serene ride for which Rolls-Royces are renowned. The turbocharged aluminum V8 engine displaces a whopping 6.75 liters and produces between 300 and 400 hp—Rolls-Royce won't quote exact horsepower figures. With turbo boost coming on, according to Technical Support Manager John Hill, somewhere around 2,500 rpm, there is no discernible turbo lag—or whine in the silent interior, for that matter. The sporty handling is accomplished without sacrificing ride quality by an increase in roll stiffness—beefed up stabilizer bars—as well as the addition of a Panhard rod attached to the subframe in the rear and an increased rate in the self-leveling suspension, according

*Continued*



A strong valve train gives Honda's 400-cc engine a 12,250-rpm redline and a specific output of 142.5 hp per liter.





# Why radar makes mistakes. How to protect yourself.

**A**lthough nine different errors have been documented for traffic radar, the most common source of wrongful tickets is mistaken identity.

It's hard to believe, but traffic radar does not identify which vehicle is responsible for the speed being displayed. It shows only a speed number and nothing else. The radar operator must decide who is to blame.

## How radar works

The radar gun is aimed at traffic and it transmits a beam of invisible radar waves. Each moving object within range reflects these invisible waves back to the radar gun. Using the Doppler principle, the radar calculates speed from the reflected waves.

## Traffic radar is blind

Traffic radar works differently from military, air-traffic-control, and weather radars. The others use rotating dish antennas in order to track many objects simultaneously.

Traffic radar uses a far smaller, far cheaper, gun-shaped antenna. This simplification requires traffic radar to ignore all reflections but the strongest. The number displayed is speed calculated from the strongest reflection.

## The best guess

Remember, these reflections are invisible. Truck reflections can be ten times stronger than car reflections. How can the operator know for sure which vehicle is responsible for the number?

The truth is, he can't be sure in many cases. The result is mistaken identity. You can be ticketed for somebody else's reflection.

## Self defense

The only way to defend yourself against these wrongful tickets is to know when radar is operating near you. Others agree with this method. In his verdict upholding a citizen's right to use a radar detector, Judge Joseph Ryan, Superior Court, District of Columbia, wrote:

*"If government seeks to use clandestine and furtive methods to monitor citizen actions, it can ill afford to complain should the citizen insist on a method to effect his right to know he is under such surveillance."*

## We can help

We specialize in radar warning. And Escort and Passport do far more than simply find radar. Upon radar contact, the alert lamp responds and the meter shows radar signal strength. At the same time, you will hear an audio warning—pulsing slowly when the radar is weak, quicker as it strengthens, then constant as you approach close range. When you know exactly how strong the radar waves are, you'll know when the radar unit is near enough to actually have you under surveillance.

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Escort and Passport are the most effective radar-warning instruments available. But don't take our word for it. *Car and Driver*, *Popular Mechanics* and *Roundel* magazines have each published independent tests of radar detectors. And each gave us the highest ratings. Just call us toll-free and we'll send reprints of the complete tests, not just excerpts or quotes.

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Since radar displays only one number, the operator has the responsibility to decide which vehicle is being clocked.





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\*Based on calendar year manufacturers' reported retail deliveries through Sept. '88.

\*\*Based on 1988 New Car And Truck Buyer Study.



**FORD PICKUPS**  
BUILT FORD TOUGH



to Hill. Buyers apparently have not been put off by the sedan's astronomical price tag of \$149,500 and an EPA combined fuel-economy rating of 11 mpg: The company notes that production already has been sold out until well into next year, and there is a healthy waiting list of customers.

## Tired of noise

As aerodynamically minded designers continue to quiet the rush of wind noise, the din of the tires on the road becomes a problem. But evaluating an experimental tire design for noise can take as much as a month, and results are subjective. It starts with meticulously hand cutting a set of four tires, followed by extensive testing with specially trained listeners riding in test cars at various speeds.

Engineers at The Uniroyal Goodrich Tire Co. have taken a shortcut in developing new tire designs with a noise simulator that evaluates as many as 10 designs a day—all without having to make a single real tire. "It allows us to predict the noise levels of a tread pattern at various operating speeds using just an engineering drawing," says David G. Caruso, tire development engineer at Uniroyal Goodrich.

An IBM personal computer reads the tire's footprint, looking at the position of the rubber tread blocks and the voids between them. Caruso explains that is where the noise is generated. The Uniroyal Goodrich noise simulator predicts the level and quality of the *tire noise* and plays it for engineers through an amplifier, graphic equalizer, and speakers. Side-by-side comparisons of designs are then made.



Prototype of BMW's new 850 CSi is caught by the spy photographer's shutter during testing. It will have perma-

nent four-wheel drive powered by a 300-hp 12-cylinder power plant. Early estimates give it a 180-mph top speed.

The first tire-tread pattern honed using this technique is Goodrich's Touring T/A, which is offered as original equipment on some 1989 GM models. When the Touring T/A's first experimental design was evaluated with the simulator, an annoying rhythmic noise something like a cat loudly purring was apparent. The tire was modified by offsetting the tread blocks to deaden some of the road impact. This was done before any prototypes of the tire were made or driven.

But designing a tire for how it will sound can disrupt how it will drive. Caruso says, "Chasing a tire's noise ghost can adversely affect the tire's traction. There is always a trade-off."

## Prairie power

Nissan premiered a new sleek van called the Prairie at the Paris auto show. It will be sold in the United States as the Axxess and will be available in either front-wheel or four-wheel drive. Nissan describes the styling for the new van as emulating the *Shin-*

kansen shape. *Shinkansen* is the Japanese word for the famed bullet trains that routinely travel at more than 100 mph. The van has a 0.36 coefficient of drag—low for a vehicle of this type. U.S. versions of the vehicle will have engines with fuel-injection systems designed to work with catalytic converters. Four-wheel-drive versions of the van feature a "super toe control" rear suspension. Nissan says this is "a passive compliance steering design that closely approximates the performance of active rear-wheel-steering systems."

## Chrysler's V6

Chrysler unveiled its new 3.3-liter 60-degree V6, which is said to be slated to power a variety of future projects. Multivalve versions are in the works, say Chrysler engineers.

## Plastic chassis

General Motors says it has licked all the problems with a structural plastic chassis—including crash testing—with an experimental Kevlar-aramid-fiber/epoxy-graphite chassis. The research program points to future cage-and-panel cars such as the now-defunct Fiero, except using all-plastic frames as well as skin.

## Old and new

Detroit Diesel Corp.'s 50-year-old six-cylinder two-cycle diesel power house has entered the electronics era. The elderly truck engine has been fitted with Detroit Diesel's second-generation computer controls, yielding up to 300 hp compared with the original 165 hp when introduced in 1938. The electronic controls monitor road speed and cruise control and can be recalibrated to change the engine's output. Other improvements include larger injectors and fuel pumps, a free-flow exhaust system, and more-efficient lubrication.

P 5



The Bentley Turbo R from Rolls-Royce displays its ultra-luxury sport sedan split personality on a high-speed cor-

nering maneuver. With a 6.7-second 0-to-60-mph time, you'd never know that it weighs more than 5,000 pounds.



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# Electronics Newsfront

By WILLIAM J. HAWKINS

## Peek a view

"It takes a minute or two before your eyes adjust," says Steve Lipsey, vice president of marketing for Reflection Technology (171 Third St., Cambridge, Mass. 02141). He carefully helps me put on a headband that supports a tiny video screen called Private Eye. As reported in the December 1988 "Electronic Newsfront," the postage-stamp-size screen is capable of displaying graphics and text with the clarity of a 12-inch screen observed from two feet away. Lipsey refuses to explain how it works, but this month I got to try Private Eye—and take a guess at what's inside.

I first squint, then stare into its tiny viewfinder with one eye closed tightly. "Open both eyes," Lipsey tells me. "Relax." I do, and in about a minute the computer-created image I see of a human heart is clear, distinct, and "floating" as I gaze around the room. Now Lipsey holds up a picture of another heart... and slowly I'm able to blend the two images together, my mind forming an instant comparison of details between the computer graphics and the picture Lipsey holds. "If you were a surgeon," says Lipsey, "the computer could show you where to start cutting. Or more realistically, the display could show the patient's vital signs as you work."

Of course the clever screen could be used in a variety of ways—from a portable PC with a headband screen to an on-the-wrist videophone that Dick Tracy would envy. But how does it work? I could only guess from what I see—and feel—and from what little clues Lipsey gives.

The display is red. Lipsey says it could be green also, but blue (for creating a color display) is not yet possible. The resolution—720 by 280 pixels—can be easily increased, according to Lipsey, and high resolutions can be achieved "depending on yield." One last clue: The device vibrates slightly. My guess: a single array of 280 LEDs that's servo driven (directly or through a mirror) down the viewing screen



An eyeful: Computer graphics and text at 80 characters by 22 lines are easily visible on Private Eye.

every  $\frac{1}{60}$  of a second. If I'm right, you read it first here. If I'm wrong... it won't be the first time.

## An earful of video

What will be new for video this year? Probably audio. All the major networks are broadcasting in stereo, giving TV and VCR makers an opportunity to create all-new stereo and Dolby surround-sound (left, right, and rear channels) products. An early participant: Akai's

VS-A77U VCR. It has a built-in Dolby surround-sound decoder and 10-watt amplifier.

## Eureka! It's HDTV

When French president Francois Mitterrand suggested three years ago that European companies work together on high-technology research and development, he sparked 600 industrial companies from 19 countries into action. The project is called Eureka, and I saw the first results at the International Broadcasting Convention in Brighton, England: a complete 1,250-line 50-hertz high-definition compatible TV system that will likely become the standard for satellite delivery in Europe. One of the principal companies is Thomson, which intends to produce the HDTV tubes and D2-MAC sets in 1990.

## Three for your PC

- Toshiba's P231SLC is a 24-pin letter-quality printer with the ability to print in black and seven colors: orange, green, purple, yellow, cyan, magenta, and brown. Standard fonts are

built in, and others can be added via a disk or plug-in font cards. What I like best about the agile printer is its ability to simulate quickly other printer brands, which made it work easily with all my software. At the push of a but-

*Continued*

Super sound: Akai's VS-A77U VCR has a built-in Dolby surround-sound decoder and a 10-watt amplifier.





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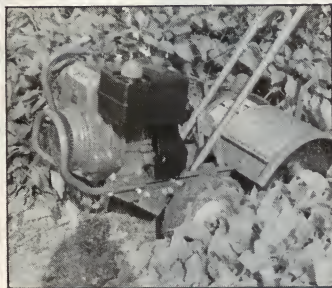
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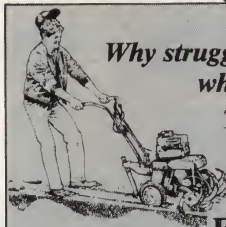
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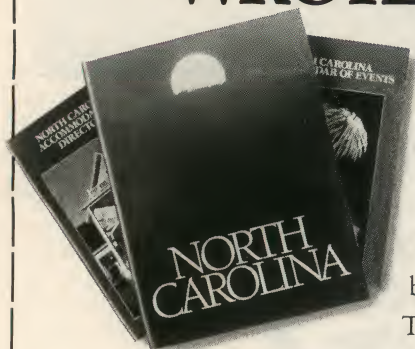
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## Electronics Newsfront

Continued

ton (there are no DIP switches), the Toshiba simulates a Qume, IBM ProPrinter, Graphics Printer, or Color Printer. Also, it becomes an Epson LQ series or JX-80 via optional plug-in emulation cards. With built-in tractor feed and 32-kilobyte memory, it's \$949 from Toshiba America (Information Systems Division, 9740 Irvine Blvd., Irvine, Calif. 92718).

- Take the normal WordStar word-processing program, then add about 300 new features to it. Result: MicroPro's WordStar Professional Release 5. Column-mode writing, automatic formatting, standard or pull-down menus, and a page preview that shows up to 144 pages at a time on the screen are a few additions that make the package a strong contender for the desktop publishing area. I like the speed and ease with which this new version of WordStar does its job—and I'm an avid WordStar user—but I believe MicroPro has broken a cardinal rule: The files created by WordStar Professional are not compatible with earlier releases of WordStar. The files contain printer information for use on a network. The package is \$495 from MicroPro International Corp. (33 San Pablo Ave., San Rafael, Calif. 94903).

- Attach a color video camera or VCR to your PC-compatible or Mac IIgs computer via Digital Vision's ComputerEyes video digitizer. Then you can capture color images on a disk for retrieval, display, or editing. It's \$400 for the PC version, \$250 for the Apple from Digital Vision (66 Eastern Ave., Dedham, Mass. 02026).

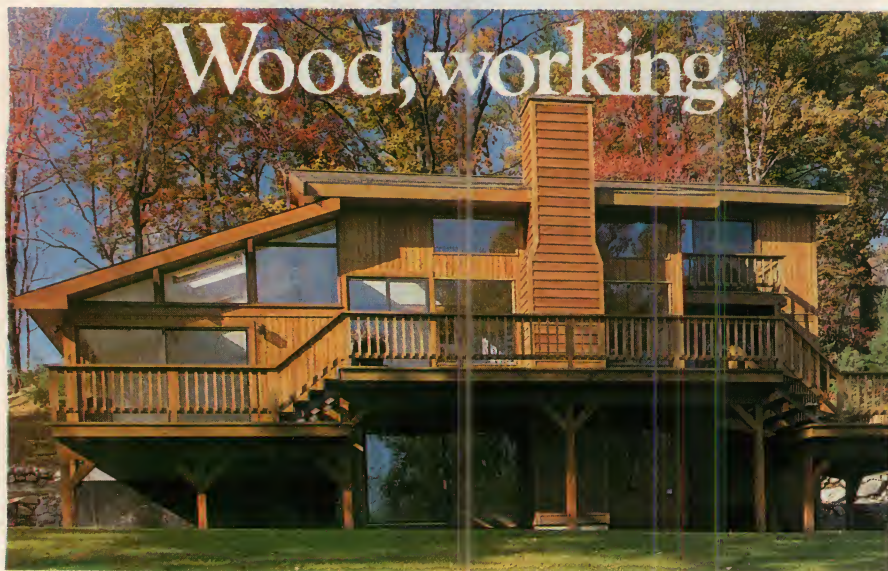
### Smarter smart card

Codercard Inc., of Santa Ana, Calif., has developed a wallet-size super-smart card to meet the stringent computer safeguards now imposed by the U.S. Treasury Department, the National Security Agency, and the National Institute of Standards and Technology. The card identifies individuals for computer access by storing up to four billion passwords, the user's fingerprints, and pertinent questions about their background. The American Access card—don't leave home without it.

### Surrounded by sound

How do you completely enclose yourself inside a 200-watt audio system? Easy, says General Motors. Buy a Cadillac. The new cars have an optional Bose Gold Series audio system with cassette or CD player. A floor-mounted DAT player is available as a dealer-installed option.

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# Save Gas, Save Engine with 'POLY'

DOUBLE GUARANTEE (See Details Below)

The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

**WHAT IS POLY?** "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man. **The 1988 Guinness Book of World Records (pg. 182) says:** "The lowest coefficient of static and dynamic friction of any solid is 0.02, in the case of Polytetrafluoroethylene -equivalent to wet ice on ice. It was first manufactured in quantity by E.I. duPont in 1943, and is marketed as Teflon".

The PetroLyn Corporation, makers of Slick 50, have invented a way to permanently bind this slippery chemical to your engine with one treatment. All you do is add one quart of Slick 50 to your oil during oil and filter change. By reducing engine friction, Slick 50 increases gas mileage and horsepower and reduces engine operating temperature thus causing your oil and engine to last longer. Just as important, it reduces metal wear, defraying costly overhauls.

**Slick 50's credentials are impressive.**

"Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon...Slick 50 does exactly what PetroLyn claims it does." Consumers Digest, (March/April 1982, p. 35)

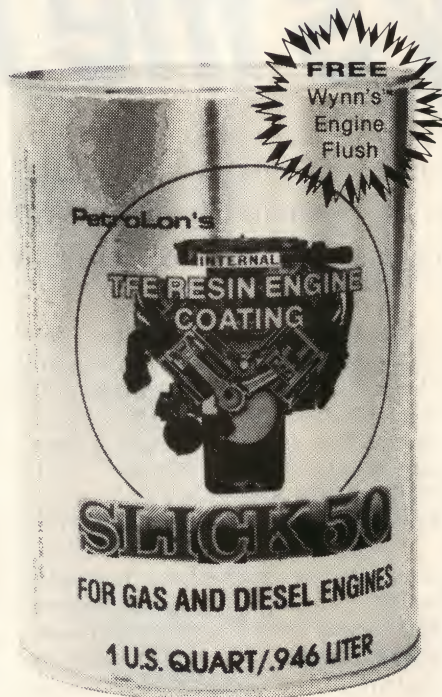
Researchers at a **nationally respected research laboratory**, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLyn Slick 50 'Poly' resin coating to also be removed, but later found it was still there."

**The Federal Aviation Administration** has fully accepted a similar product—Slick 50 Aircraft Treatment (F.A.R. #33.49).

**TUV, a German testing laboratory** with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

A test done at the **San Diego State University** revealed that, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps the most dramatic of all is a **torture test overseen by the Automotive Services Council for Pennsylvania**. This test was shown on television station WTVE: Three cars with between 75,000 and 129,000 miles on them, were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about half an hour. The water temperature never rose and the engines sustained no apparent damage.



**How do you give an engine a "poly" treatment?** Very simply! Just before an oil and filter change, add Wynn's™ Engine Flush (sent **free with each order**) to clean out your engine. Then drain your oil, change the filter, and add the proper amount of oil less one quart. Add one quart of Slick 50, drive for thirty minutes, and leave it in the crankcase for 3,000 miles. (Add two quarts for engines with oil capacities of seven quarts or more.)

Slick 50 gives a permanent coating so you need to treat your engine only once, and not each time you change your oil. Slick 50 is also excellent for turbocharged engines, aluminum block engines and rotary engines.

**Will it work with most oil?** Yes! Slick 50 will work with all petroleum-based oils and synthetics compatible with petroleum based oils.

**What are the benefits of Slick 50?** Your actual benefits in percentages may vary, depending on the kind of driving you do, the condition of your vehicle, etc. By reducing friction, Slick 50 does all of the following: Slick 50 **increases gas mileage**. Slick 50 **increases horsepower** - small economy cars and large RV's really need this! Slick 50 **makes for easier starting** (important in cold weather.) Slick 50 **reduces operating temperatures**, thus increasing the lubrication of your oil and the life of your engine. Since lubricating lead is being removed from gas, and unleaded gas is poor in lubricating qualities, **this extra lubrication of Slick 50 on valve systems and guides is a real bonus.**

**Last, but not least, the drastic reduction in engine wear can delay costly overhauls.** These can often cost well over \$1,000. Slick 50 eliminates the "lubrication starvation" that all cars experience when you first start them, before the oil has a chance

to circulate. Up to 90% of the wear on a car can be caused by this lubrication starvation. You receive all these benefits for less than the cost of two tanks of gas (\$39.95).

**Will Slick 50 harm my engine or affect my warranty?** No! Slick 50 is suspended in an excellent grade of petroleum oil which meets, or exceeds, every manufacturer's engine warranty requirements. In addition, this oil carries an API (American Petroleum Institute) service classification SF-CC-CD.

**More Slick 50 products are available.** These include Gear Treatment (manual transmission, etc.) 2-Cycle Engine Treatment, Grease, Fuel Conditioner, and Power Boost. Free information sent on request.

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Guaranteed lowest price and guaranteed satisfaction. If at the time of purchase you have seen Slick 50 advertised in a current magazine at a lower price, we will beat that price by \$2.00 a quart and you will still get your free engine flush. If you are not satisfied with our Slick 50, within 4 months, send us a note and proof of purchase for a full refund of purchase price. This makes trying Slick 50 **RISK FREE** to you. We have been in business for 10 years and intend to keep our customers happy.

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# The sky's the limit

A computer guides every movement of this new Celestron telescope. Pick out a star by entering its coordinates. Or let the computer lead you through an automated astro show of more than 8,000 celestial objects from its three built-in catalogs.

By JOANNA ENGLE

I turn the power on, and the computer's rows of digital readouts glow red, flashing abbreviated instructions to me. I blindly follow the orders, entering the time, date, latitude, and longitude of my present location—a mountaintop in Warwick, N.Y. Suddenly a motor whirs, and I step out of the way as the massive telescope swings into action, aligning itself with Earth's rotation. Then the sound stops just as quickly: Celestron's computer-controlled Compustar telescope is ready for sky searching.

Galaxies, planets, nebulae, and constellations are at your fingertips. Using the push buttons, you enter the coordinates of what you'd like to see, and the clever scope finds it for you in seconds. Or, using the computer's three built-in electronic catalogs of over 8,000 astronomical objects, the telescope can find something by size,


type, magnitude, visual quality, or catalog number. (The built-in catalogs are the Messier Catalog of deep-space objects M1 through M110; the Computerized New General Catalog of deep-sky objects CNGC 1 through CNGC 7840; and the Reference Catalog of notable stars REF 1 through REF 218.)

Unlike other computer-aided telescopes, where the computer is an add-on, this is a completely integrated system, which gives it more capabilities. For example, the most distinctive feature of the Compustar is that it can take you on a tour of the universe. I instructed the computer to go to all nebulae brighter than a magnitude of 15 (faint), and the telescope scanned the sky, pausing for as long as I wanted at each object it found.

Setting up the telescope is relatively easy, but a diagram in the user's manual labeling the parts of the scope would be helpful to novices. The computer guides you through the polar-

alignment process, and—as I learned—it's essential to begin with the telescope lined up on the North Star. To save time I first tried setting up the telescope during the day and guessed at the star's position. Big mistake. When I was finished, the scope flipped upside down.


The Compustar requires lots of power: 12 volts at 12 amps. Celestron suggests you use a deep-cycle storage battery such as those used on marine and recreational vehicles. (I originally used a car battery, but it discharged in a little over an hour.) If you intend to use the telescope in a non-remote area—not on a desolate New York mountaintop—a 12-volt-DC power supply that plugs into a standard household outlet is available.

Compustar is available in three diameters: 8, 11, and 14 inches. Prices range from \$6,000 to \$20,000. It's made by Celestron International, Box 3578, Torrance, Calif. 90503. 





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# "Say, Smokey—"

A clinic on cars by Smokey Yunick, America's most famous mechanic

## Stumbling Somerset

My 1987 Buick Somerset equipped with a three-liter V6 engine has a disconcerting miss. I've been back to the Buick dealer several times in the past year and a half. Each time the mechanics say the engine checks out OK. When driving on a level road, however, it starts to buck or miss, mostly after the torque converter locks up at about 37 mph. The engine misfire is the most noticeable between 40 and 50 mph. Help!

Wallace Balla, Greenwich, Conn.

*I don't think there is a quick fix for your car that would be emissions legal. Your problem is that at low manifold pressure and mild load the gas-air mixture is too lean. The main goals of the computer program that controls the engine are to pass emissions testing and get the best gas mileage, regardless of the*

*effect on performance. To do that at high load and low rpm, it is fuel stingy. This, in addition to EGR under these conditions, increases the possibility of isolated engine-cylinder misfire. Simply stated, it is a pretty sorry engineering job, but General Motors is not alone in this problem. The only practical fix is to swap the car for one that operates better under your driving conditions. When looking into buying a car, always test-drive it under road conditions you would encounter. If the dealer won't let you drive it, don't buy it. A sharp technician can make your car run with custom engine work, but I doubt that the average consumer can afford it.*

## Colt with no fittings

I have a 1987 Colt that has no grease fittings on the chassis. The garage attendant says the places it needs to be greased are sealed, and they should

have enough grease to last the life of the car. Does this mean the car was built to last 100,000 miles, and when this grease wears out its chassis cannot be lubricated? Is there a way to get grease into these parts?

L. E. Donaldson, Moro, Ill.

*Yes, that's the way it is on almost all cars built these days. Lubricated points are greased and then sealed for life against dirt and weather. As a rule, vehicles that operate on typical roads in average service make it to the junkyard for reasons other than the lack of chassis lubrication. I think the use of sealed lubrication systems has made maintaining such cars cheaper as opposed to those requiring periodic greasing.*

## Surging Charger

I have a 1987 Dodge Charger equipped with a 2.2-liter engine and carburetor.

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It has 2,000 miles on it. Ever since I bought the car, the engine speed surges while I'm driving on the highway. I have complained to the dealer a number of times, and his answer is to use alcohol-free gasoline always. I do this and it has helped, but the engine still surges. Can you tell me what is causing this, and is there a fix for this problem?

John Spoltman, Woodburn, Ind.

*An engine that surges during steady-state driving usually has either a fuel mixture that is too lean, too much exhaust-gas recirculation (EGR), or ignition timing that has moved out of specification. A good way to pin it down is to put the car on a chassis dynamometer. If that equipment is not available, the engine can be checked by analyzing the exhaust gas during operation.*

### Motor-home maintenance

I have a small 1981 Marque motor home built on a 1979 Chrysler chassis. It has a 360-cubic-inch V8 engine with a four-barrel carburetor. I only use it for a few tailgate parties and

two long trips each year. When I take it out of storage at the end of winter, at least one brake caliper is usually frozen. What can I do?

Joseph Messina, Brooklyn, N.Y.

*Flushing brake fluid through the hydraulic system and using high-temperature premium brake fluid is one minimal aid. Giving the motor home a ride around the block once a month would help quite a bit as well. The longer it sits, the worse the oxidation gets on all parts. Using your motor home more frequently can clean mild oxidation and prevent some of your problems. If you replace the standard brake parts with stainless-steel pistons and piston sleeves, it flat out stops oxidation.*

### Shift stalling


My 1987 2.8-liter V6 Cavalier Z-24 has gradually developed the habit of stalling when I shift it into gear and put load on the engine. This only happens when the car has been sitting overnight. If I let the engine run unloaded for 15 to 30 seconds and then put the car into gear, it usually does not stall,

although it will run rough for a few seconds. At all other times it runs perfectly. My Chevrolet dealer has no idea why this is happening, so he recommended a tuneup—which he did, with no effect. Another Z-24 owner told me he had the same problem and was never able to get it resolved. What do you think the problem is, and how can it be fixed?

John Horst, Moretown, Vt.

*The mixture on cold start is too lean. Your engine is computer controlled with reference to fuel, ignition, and emissions. The engine has many sensors that talk to the computer. All cold engines need a little extra-rich fuel-air mixture to start. There is also a critical emissions problem, with the mixture being important to hold emissions to an absolute minimum. Your problem must be examined with an engine analyzer for fuel mixture, ignition, and timing when the engine is cold started.*

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.



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# Biobarrier inhibits root growth

A new product from the nuclear industry has been developed to help farmers struggling with clogged underground crop irrigation systems.

Though buried drip irrigation systems are efficient and cost effective, many farmers find them impractical

over the long run because plant roots following the water source stop up emitters, causing damage and costly repairs. Rootguard effectively inhibits root growth in such systems, making them root- and worry-free.

Marketed by Agrifim Export

through a licensing agreement with Battelle Memorial Institute, Rootguard incorporates a "biobarrier" technology originally developed by Battelle's Pacific Northwest Laboratories to keep roots from finding their way into buried low-level radioactive waste disposal sites. By combining polymers with a herbicide, Battelle created long-term controlled-release devices, or biobarriers, that inhibit plant roots.

Agrifim created an application for this technology in buried drip irrigation systems by incorporating the herbicide Treflan into a plastic drip emitter nozzle.

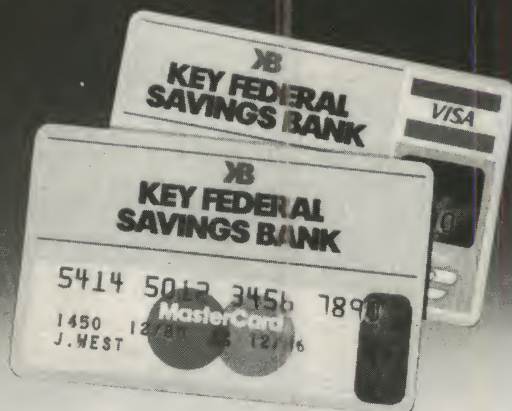
"The problem with varying drip systems has always been the intrusion of roots. But putting a herbicide through the system once every six months has never been practical," explains Rodney Ruskin, president of Agrifim. "With Battelle's slow-release technology it became practical to actually put the herbicide into the plastic nozzle."

Rootguard, manufactured from virgin polypropylene copolymer, continuously releases minute quantities of Treflan into the soil. Laboratory analysis has shown the release rate into the soil to be approximately one microgram per dripper per day at 54 degrees F.

What makes Treflan suitable for this application is the nature of the herbicide. "It is adsorbed by the clay particles in the soil around the dripper," explains Ruskin, "so it doesn't move through the soil. And it doesn't dissolve in water, so it doesn't pass into the water system. It just decomposes in the soil and volatilizes." The herbicide, registered with and approved by the Environmental Protection Agency for the Rootguard application, was chosen for its effectiveness and minimal environmental impact. Treflan is said to be harmless to birds, mammals, and insects. And it doesn't kill plant roots but prevents longitudinal root growth, so roots are diverted around the emitters.

Agrifim guarantees Rootguard for 10 years and claims a minimum life expectancy of 25 years at 59 degrees F and 12½ years at 68 degrees F. Agrifim also markets the Rootguard ring, which clips onto most drip emitters and will release Treflan at a constant rate over 10 years. Agrifim Export, 211 Sutter St., San Francisco, Calif. 94108.—Cheryl M. Fiorillo

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# Concrete that sleeps

Concrete is good stuff. Mix it, pour it in a mold, and it hardens like rock. But for builders concrete has one drawback: Once it's mixed there's almost no way to prevent it from hardening. Every year millions of cubic yards of concrete harden unused in dump sites and in stalled delivery trucks.

Now researchers at Master Builders in Cleveland, Ohio, have developed a technique that keeps concrete plastic indefinitely—making possible its storage and later use.

The system, called Delvo, works by the addition of two proprietary chemicals that alternately suspend and reactivate the hydration of cement in a concrete mix. The stabilizer additive coats cement particles and prevents them from reacting with the water. When the contractor is ready, the activator chemical removes the coating and allows curing to proceed normally. Says Greg S. Bobrowski, one of Delvo's inventors: "The stabilizer puts the concrete to sleep, and the activator wakes it up."



Delvo also lets builders reuse slurry water—the concrete water solution created when delivery trucks are cleaned—in subsequent mixes. Normally the 300 gallons of water used to clean each truck are dumped. But when mixed with the rinse the stabilizer eases the removal of concrete residue and cuts the amount of water needed to do the job by 80 percent.—*Eduardo R. C. Capulong*



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—*Don Sanderson, Systems Consultant*

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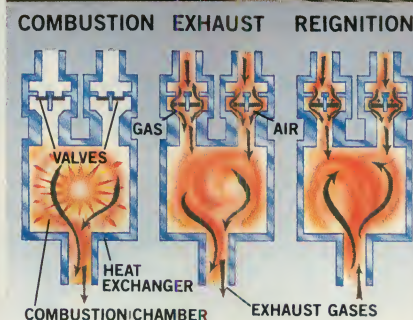
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# Pulsing room heater

Last month, Empire Comfort Systems introduced a gas heater that brings pulse-combustion technology to apartments, condominiums, and single-family homes without ductwork. As the first "pulsing" appliance meant for installation in living areas, the Empulse space heater provides high-efficiency heating without a chimney.

The space heater works more like a car engine than a conventional furnace (see drawing). Combustion is so complete that more than 90 percent of the gas's heat energy is released and transferred to living space. Because it doesn't need a chimney—flue gases are forced outside by the combustion process through a two-inch plastic pipe—additional heat is captured by cooling the exhaust gases to below 130 degrees F. That condenses the water vapor in the gases, capturing latent heat. The condensate is then reevaporated to humidify the air.



DRAWING BY BOB LANGE

In pulse combustion, valves send small amounts of gas and air to the combus-

The Empulse will be capable of 18,000 Btu/h heat output. Engineers at the American Gas Association say it could cost one quarter of what it takes to operate an electric space heat-

tion chamber, where they mix. A spark ignites the initial mixture, and an explosion (left) causes the valves to close. Hot gases swirl in the chamber and out the exhaust pipe. Heat is transferred via a heat exchanger (center). As gases rush out, pressure in the chamber drops, reopening the valves to let in more gas and air. Meanwhile, the hot exhaust gases rush back and reignite the mixture (right).

er. The heater can run on natural gas or propane and can be installed up to 15 feet from its vent termination. Empire Comfort Systems, Belleville, Ill. —Eduardo R. C. Capulong



Everyday People on CompuServe

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— Gay Spencer, Labor Relations Specialist

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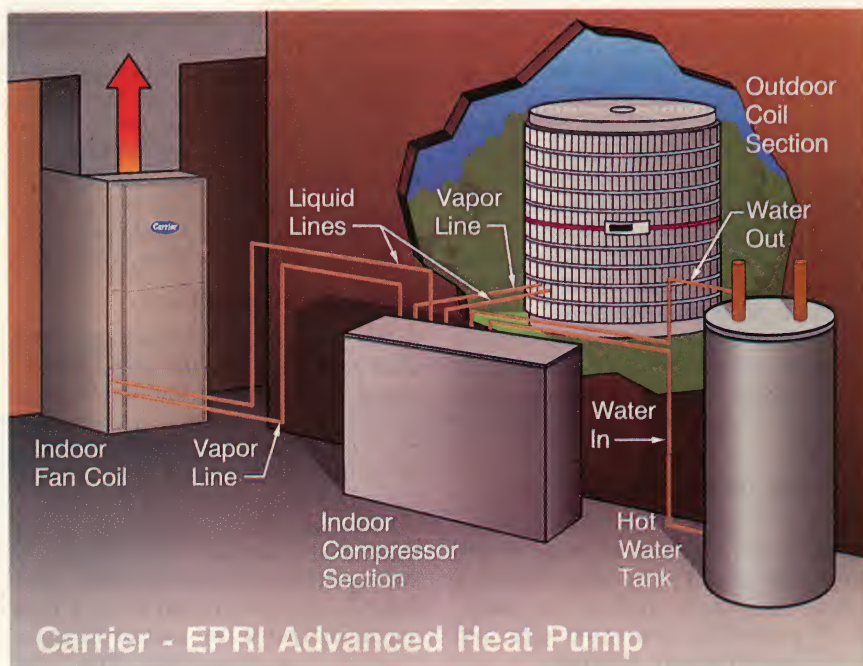
Slated for introduction this month, Carrier's newest heat pump, the Hydrotech 2000, will integrate water heating with space heating and cooling. One important benefit of its four-part setup (right) is "free" hot water during summer months as a spinoff of heat rejected in the cooling mode.

The new heat pump, whose development was sponsored by the Electric Power Research Institute, is much like the Carrier Infinity [Oct. '87]: A 16-speed compressor and multispeed indoor blower will allow it to adjust output to your home's heating and cooling needs. The variable speed not only provides for better dehumidification in the cooling mode, Carrier claims, but also makes for a more efficient heat pump that's less prone to wear.

In addition, Carrier says the pump will use a more efficient "brushless" DC motor and an indoor compressor, making trouble-shooting easier in the winter.

The Hydrotech 2000 will cost about 50 percent more than a standard heat pump—an investment that the company says will be paid back in less than five years of energy savings. Carrier Corp., Box 4808, Syracuse, N.Y. 13221.—*Eduardo R. C. Capulong*

## Advanced heat pump heats water too



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— Greg Trotter, College Student

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# Radial and bias-ply tires: nix on mix?

*Auto experts have long warned against mixing radial and bias-ply tires, or if the two types are used, to put the radials on the rear axle. In "What's News" [Oct.'87], Editor-in-Chief C. P. Gilmore cited a study by Floyd S. Conant and Richard L. Fuller of Standards Testing Laboratories that reported no harm in any mix of tires of equivalent size. Two rebuttals followed—from Armstrong Tire Co. and the Tire Safety Council. So in his November column Gilmore asked readers: Does mixing affect handling? Some responses were printed in January '88's "Readers Talk Back." And now, the rest of the votes are in...*

## Driving like a drunk

I owned a '72 or '73 Plymouth Duster with Goodyear E78-14 bias-belted tires. One year I put a set of Mohawk steel radial snow tires on the rear. I don't remember the exact size, but they were probably 195-14s.

The car was almost undrivable—even people who don't usually notice alignment problems commented on it after using the car. Evidently the bias and radials reacted differently to slight changes in the road surface. The bias tires on the front would hit an irregularity and shift to one side, while the radials on the rear would hit the same spot and shift a different amount. The car wandered back and forth as if it was being driven by a drunk.

After a couple of months I bought radials for the front. That fixed the problem.

John Rieman, Lakewood, Colo.

## Early tire failure

Weight, air pressure, and size being equal, the one variable besides traction is heat dissipation. Because premature tire failure occurs when bias and radial tires are paired, I am adverse to indiscriminate mixing and support the National Highway Traffic Safety Administration position.

P. M. Prosper, Arcadia, Calif.

## The safety factor

I have operated many front-wheel-drive vehicles with tires of the same size but different tread patterns mounted on the front; the cars pulled to one side when accelerating and to the other when decelerating. I believe this proves that, when put to performance with the same area of contact, different tires have different coeffi-

cients of friction. While I'm sure Conant and Fuller's findings are of value, I disagree with the way they were presented in POPULAR SCIENCE. "Myth" and "baloney" are improper terms to use when safety is at issue. In fact, neither Conant nor Fuller could deny that using the same tires all around may help avoid an accident and save a life.

Sal Yazbeck, New Brunswick, N.J.

## Mixing? No problem

A few years ago I was driving a 1975 Cadillac Coupe de Ville with LR78-15 radial tires. When I had to change a front tire on a thruway with a spare cross-ply L78-15 I could detect no handling differences. Mind you, I do not attempt hairpin turns at 80 mph.

I suspect that the no-mixing recommendations are not really necessary. Perhaps they sell more tires. My present cars all have radial tires. I have not investigated the matter further.

R. J. Armstrong, Erin, Ont.

## GM unconvinced

I think your readers deserve another perspective on the claim that mixing bias and radial tires may be safe. General Motors owners' manuals are clear on this score. They read: "CAUTION: Do not mix different tire construction types... on your car except in emergencies because your car's handling could be affected and may result in loss of control. This caution does not apply to a compact spare tire furnished with your car." The spare is designed to be used with radial road tires.

We have reviewed the Standards Testing Laboratories' paper and do not believe it justifies changing our position.

Robert J. Higgins  
Tire-Wheel Systems  
General Motors Corp.  
Milford Proving Ground  
Milford, Mich.

## Steering surplus

I agree with manufacturers' recommendations. I put two new high-quality radials on the front wheels of a small Honda sedan and left bias tires on the rear. This made the quick steering quicker, so I was oversteering, especially at highway speed. When I replaced the bias-ply tires on the rear with radials, the handling improved considerably.

Howard Olsen, Hilo, Hawaii

My 1968 Mercury Cougar went from understeer to oversteer after I put two new radials on the front and left the original bias plies on the rear. It was hairy in the rain!

Larry Larsen, San Antonio, Texas

Mix radial and bias tires? Not on my car, you don't. In 1973 I was in the U.S. Army and stationed at Ft. Leavenworth in Kansas. As the winter approached I began shopping for snow tires for my 1970 Fiat 850 Spider. I asked about mixing treads, but the only "no no" I was told was not to mix them on the same axle. Because my budget was tight, I used bias snow tires on the rear.

The first morning I drove with the bias tires, I almost wrecked the Fiat. When I turned the steering wheel to the left, the car felt as if it would make an abrupt 180-degree turn. On a four-lane road, the car shot across to the far left lane from the far right before I could react.

I managed not to damage the car that winter. When spring came, I replaced the bias-ply tires with the old radials, and the car reverted to its normal self.

Paul L. Rawls, Nashville, Tenn.

## Mix effects explained

To understand the safety implications of mixing tire types, consider that when a car turns there's a difference between the direction a tire is pointed and where it travels. This difference, called slip angle, is directly related to the sideways force needed to take the car off a straight-ahead path. When a car turns, the slip angles assume some magnitude, depending on tire construction, weight on the tire, its tread, and road characteristics. If a tire has good traction, the angle is small; but it can approach 90 degrees on wet or icy pavement. If the rear slip angle is greater than the front, the result is oversteer. A tighter turn increases the slip angles and the front-to-rear difference, further tightening the turn and possibly resulting in a spin out. The stiffening effect of the belts keeps the part of the tire in contact with the road more in line with the rest of the tire, reducing slip angle. So radials should always be on the rear when mixing type.

A significant side-to-side difference in slip angles will also tend to cause greater wear on the tire with characteristically smaller slip angle, because the actual slip angle will be the same for both. Rear-engine cars are especially vulnerable to this because the greater rear weight means greater rear slip angle.

James Yost, Boston, Mass.



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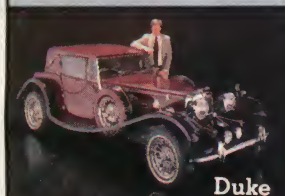
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# AMERICA'S TRUCKS

## *muscle and comfort*

By DAN McCOSH  
*Detroit Editor*



PHOTO BY JOHN B. CARNETT

**P**ickup trucks have been getting a little fancy these days, sporting innovations such as electronic fuel injection, anti-lock brakes, and improved suspensions, like some good old boy pulling his best pink sport coat out of the closet for the Saturday night dance.

This raises a question: Is the modern pickup gradually becoming less of a workhorse as it gets modern technology and comforts? Or has a smattering of today's automotive engineering merely taken some of the hair-shirt qualities out of trucks, making them more comfortable as well as more serviceable?

It's easy to trace the evolution of the pickup species by lining up the three major domestic brands. Dodge pickups were last redesigned in 1972, but have had frequent upgrades, including fuel injection and anti-lock brakes for 1989. Ford gave its pickups a face lift and anti-lock brakes in 1987, followed by across-the-board fuel injection

in 1988. Early in 1987 Chevrolet and its sister division GMC unveiled a completely reengineered full-size pickup, now in its second model year.

The POPULAR SCIENCE test team put full-size V8-powered pickups from the Big Three through our handling and performance grid, an exercise that we expected would test how well the new pickups keep up with passenger-car traffic. In addition, we tested them for acceleration and braking, both with their cargo boxes empty and loaded down with a one-ton payload. Finally, to test the worth of the new anti-lock braking systems, we gave each pickup a workout on a wet road surface. The results were sometimes surprising.

### **V8 power**

Our test Chevy, Ford, and Dodge pickups were equipped with V8s displacing 5.7 liters, 5.0 liters, and 5.9 liters, respectively. These are all old-line V8 engine blocks that recently have been upgraded with computer

control. Electronic fuel injection has been late in coming to the pickup arena, mainly because of cost and the potential for service problems. But new federal regulations on truck emissions are encouraging fuel-injection systems, and their reliability has been well tested in cars. The result is that the benefits of electronic fuel injection—mainly improved drivability and fuel economy—are now becoming available to truck owners.

### **Advanced fuel injection**

Dodge is the last manufacturer to enter the microchip era with its 5.9-liter V8, modified for this year with a low-pressure throttle-body fuel-injection system similar to the systems introduced last year on smaller engines. The V8 in the D250 Sweptline truck develops 190 horsepower at 4,000 rpm and a hefty 295 pound-feet of torque at a sedate 2,000 rpm.

The Chevy C2500 is powered by the 5.7-liter V8, also with throttle-body





Outfitted for tough jobs and rough terrain, this trio of trucks goes where the work is (from left): Dodge D250 Sweptline; Ford F-150 Supercab; and Chevrolet C2500 Fleetside. Rear wheel anti-lock brakes help safely stop these trucks.

fuel injection. It is rated at 210 hp at 4,000 rpm and 300 lb.-ft. of torque at 2,800 rpm—a slightly peakier engine than the larger Dodge unit.

Ford's sequential port fuel injection puts it a step ahead of the Dodge and Chevy at the cost of some additional complexity. The F-150 Supercab we tested was equipped with Ford's small-block five-liter V8, rated at 185 hp at 3,800 rpm and 270 lb.-ft. of torque at 2,400 rpm.

It's well worth noting that the Dodge and Chevy also were just under the 8,500-pound gross vehicle weight (GVW) break where each truck gets a heavy-duty engine. Oddly, when you opt for an over-8,500-pound suspension on all three trucks, the Dodge engine horsepower increases, the Chevy drops, while the Ford stays the same.

The reason for this is that crossing the 8,500-pound GVW line means the engines must meet tougher emissions standards. Chevrolet slightly detunes the engine, including a lower compres-

sion ratio. Chrysler says it will pay a penalty to the government, which allows the company to delete some of the emissions hardware. Ford's port injection system and full electronic engine controls let the engine be retuned with a slight loss of torque, but no lost horsepower—an advantage of Ford's more sophisticated electronics.

The horsepower rankings predicted the acceleration rankings—with the unloaded Chevy easily taking first place, clipping off a 10.5-second 0-to-60-mph time. The Dodge was second at 11.2 seconds, and the Ford third, taking 11.9 seconds to get to 60 mph.

The Dodge had a weight advantage over the Chevy and Ford trucks, which weighed in 223 and 294 pounds heavier, respectively. The Ford's extra heft was due to its longer wheelbase and extra sheet metal on the extended-cab version we tested. (A Ford F-150 Supercab was used for the dynamic testing when our standard F-150 [which is seen in the photo] was side-

swiped on a rainy afternoon in Detroit.)

When we dropped a one-ton payload into the cargo box, the rankings stayed in order, but the gaps widened. The Chevrolet had a respectable 13.9-second 0-to-60-mph time. The Dodge had a 15.5-second run, and the Ford came in third with a 16.7-second run. The spread is partially explained by noting that both the Chevy and Ford were equipped with four-speed automatic transmissions, while the Dodge had a three-speed automatic. The Chevy's closer-ratio four-speed gearing was a clear edge on the drag strip.

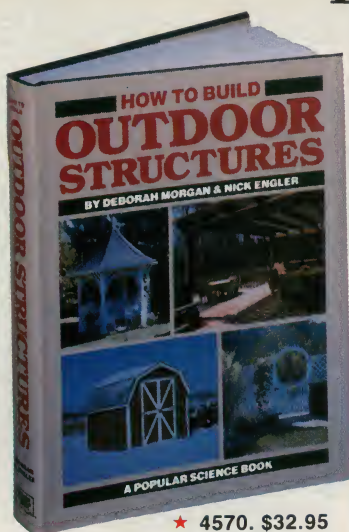
### Anti-lock brakes

The newest technical feature on these trucks is the electronic anti-lock braking system developed by Kelsey-Hayes Corp. The rear axle in a pickup is subject to a tremendous range of loads, from fully loaded to fully unloaded, and it has always been a problem to design a braking system that

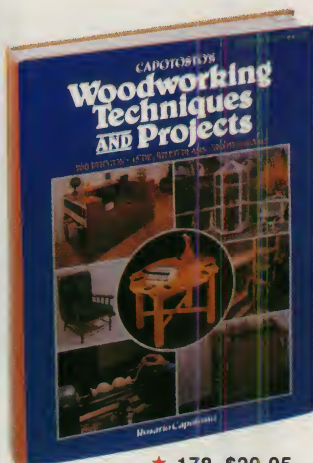
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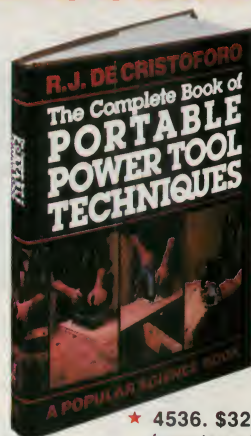
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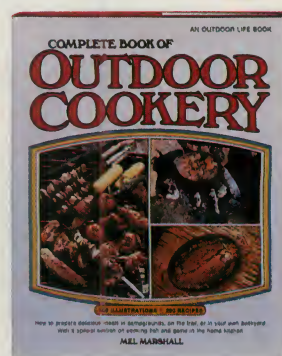
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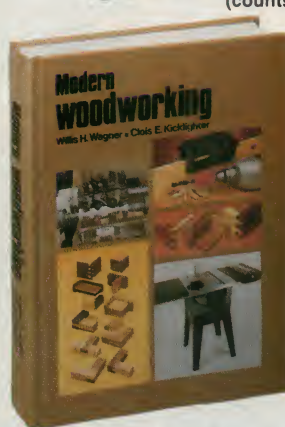
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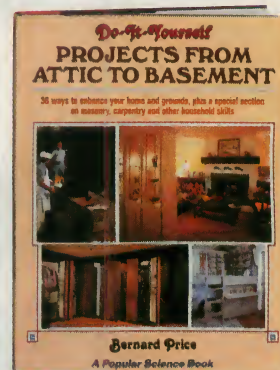
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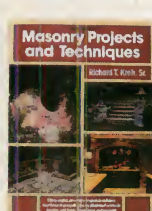
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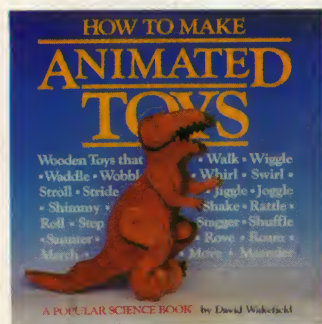
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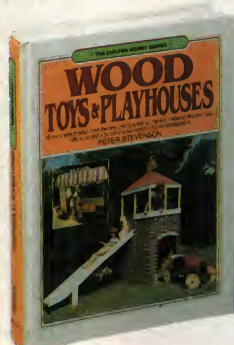
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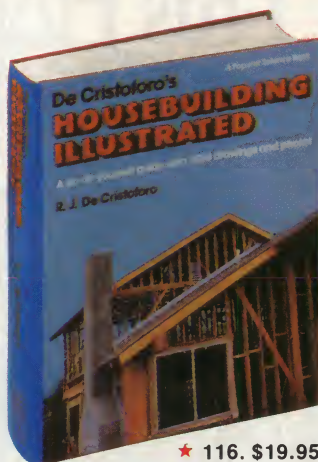
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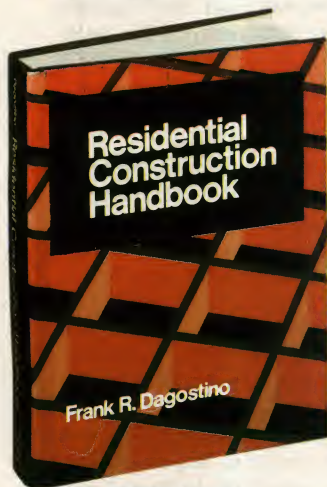
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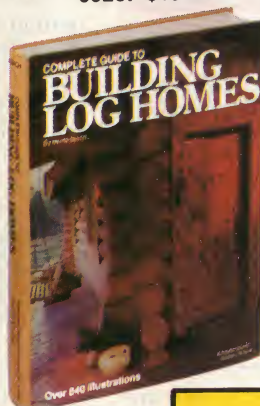
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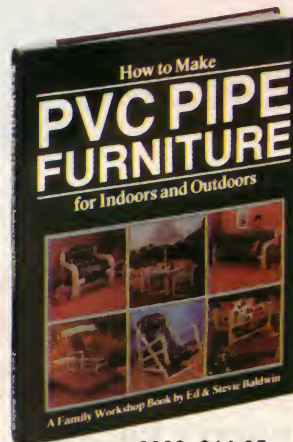
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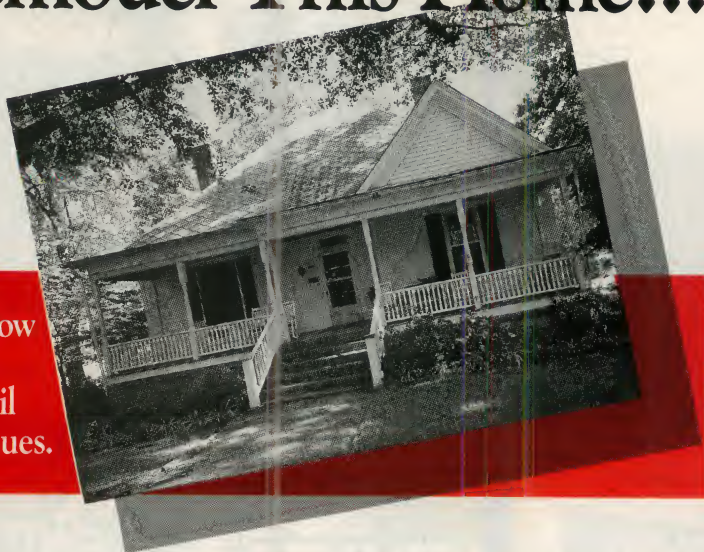


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## America's trucks *Continued*

will perform adequately under that range of conditions. Anti-lock braking solves the problem by providing optimum braking and preventing wheel lockup, especially when the rear axle is unloaded.

I got a welcome surprise trying braking maneuvers in the wet with these trucks. The Kelsey-Hayes system detects lockup only at the rear axle, and pulses brake pressure to both rear wheels at once when a skid starts.

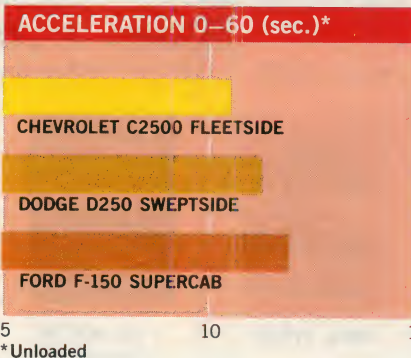
But that was sufficient to stem a runaway slide. Skidding and braking in a straight line, and even don't-try-this-at-home maneuvers such as braking while turning, were no problem for the rear-wheel anti-lock brakes. Time and again the result was the same—a hard stab on the brake pedal and the truck stopped as straight and sure as if you'd dropped an anchor out the back.

### Skid stoppers

The dynamics of the system meant the front brakes occasionally locked. This, combined with a tendency to understeer, kept the front end plowing dead ahead. One side effect prompted by this behavior was that if you lifted off of the brake pedal in a corner, the

front wheels would regain traction and the rear would start to swing out—behavior similar to lifting the throttle in a front-drive car. The effect is exactly the reverse of what you'd expect from a standard braking system, where hard braking brings the tail around.

The trio of trucks tested well on braking from 60 mph, even in the wet. On our road surface, slicked down with a spray of water, the relative ease of modulating the brakes close to lock-up seemed to affect the results. The Ford stopped in a remarkable 171 feet. Some distance behind was the Dodge at 182 feet, followed by the Chevy, whose brakes were hard to modulate, at 187 feet.



The Ford stayed well in front in braking on dry pavement as well, with a 157-foot stop, which compares well with good passenger-car stopping distance. The Dodge came to a stop in 173 feet, marginally better than the Chevrolet at 174 feet. The problem with modulation in the Chevy was less pronounced on the dry road.

The difference between the Ford and Chevy closed up when the beds were loaded with a one-ton payload, but the Dodge dropped to a distant third. With weight in the pickup bed, all the trucks in the test group experienced varying degrees of brake fade—the Dodge's being the most pronounced. This was particularly surprising considering the high gross-vehicle-weight rating of the Dodge.

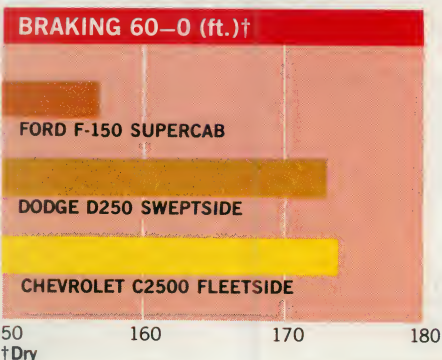
### Surprising suspensions

Another surprise came in handling maneuvers, where you don't expect much from big pickups to begin with. Dodge added gas shocks to its pickups this year, but the ride was still uncomfortable on rough roads with an empty bed.

Ford says the basic philosophy is to "build trucks as tools first, then add features for personal use," said one engineer. The Ford approach sticks with twin-I-beam front suspension, a design that uses two pivoting solid axles suspended by coil springs at the end that supports the wheel. The design is sturdy, but makes it difficult to design in subtle suspension tweaks. The current generation includes ball joints and steel stampings to improve steering response and stability, but is still slightly less precise than Chevy's upper-lower A-arm front end.

Both the Ford and Dodge stick with full ladder frames, a basic, rugged, stiff design. Chrysler is also credited with bringing two-sided galvanized steel into the truck-body business, a lead only recently followed by Chevy and Ford. Rust resistance should be dramatically enhanced.

However, crossmembers make it difficult to mount some other pieces. The new Chevy chassis leaves room to put more essential equipment between the





frame rails and broadens the base for suspension mounts—the result is efficient use of space and an improved ride, but the drawback is inherent flexibility compared with the straight ladder frame.

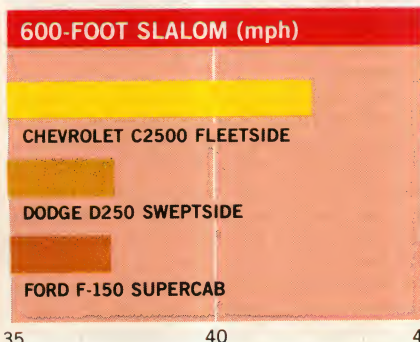
A Chevrolet engineer told me that the apparent lack of torsional rigidity was part of Chevy's campaign to improve the truck's ride. The new Chevy design also incorporates a slight taper in the box, which has caused some problems mounting box covers and campers. But Chevy has put the most into suspension revamping in recent years, lengthening the rear leaf springs and improving the front-end geometry. The result was that in both double-lane-change and slalom maneuvers, the Chevrolet pulled big margins over the competition. The Chevy tucked in as well as some sedans we've tested and steering action was precise.

### Steering feel

Less precise, but still quick in the double lane change, the Ford took a lot of cranking at the wheel. The Dodge barely beat the Ford in the slalom and tied in the double lane change. The Ram pickup had a disconcerting lack of centering action in the steering gear, which also showed up as some difficulty controlling it in a crosswind. The heavy rear spring rating of the Dodge also seemed to act like a monster sway bar, and in hard cornering caused some loss of driving traction as the inside rear wheel spun, limiting cornering speeds.

I'd rate steering feel on the highway more important than handling numbers for a pickup—although the main reason the Chevy dominated was its overall ease of steering. On the road the Chevy was steady and precise. The Ford was also steady, but more work was required to keep it in line. The Dodge pickup was sometimes skittish.

As our truck testing progressed the phrase "more like a truck" kept creeping into the conversation, which led to a discussion on just what "truckness" really is.



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If it implies toughness, the Dodge seemed to have a slight edge. While some of the difference could have resulted from the high GVW capacity of the Dodge as tested, the chassis and box also seemed to be stiffer. This was apparent when we put in the payload off-center, with the Dodge twisting the least. In contrast, the Chevy twisted noticeably, while the Ford was in the middle.

### Tough or soft

If "truckness" implies a rough ride, then the Chevy was downright untrucklike. It is soft and superior in some ways to GM full-size sedans. GM's full-size pickup has been upgraded in some important areas, including lengthened leaf springs, welded door hinges, and double-wall construction in the box—all features

that contribute to an overall tight feeling and a quiet ride. The Chevy's flush glass is a bit tougher to justify, but it does quiet down the wind.

Such refinements were decidedly lacking in the Dodge, which had a spartan vinyl interior that looked as if it could be washed out with a garden hose. The interior noise level at 60 mph was also high.

While I hold some reservations about the durability of a fabric interior, I was soothed while driving the Chevy. It's the first GM use—and one of the first applications in the world—of a new process of molding seats in foam and then bonding upholstery material directly to it. However, the high-tech instrument panel was confusing at best. Give me needle gauges any day. Overall I found the Ford the best compromise between utility and comfort.

### Best-engineered pickup

If you define good engineering as the best solution to a problem with a minimum of side effects—load versus ride comfort, for example—the full-size Chevrolet and GMC pickups may be the best engineered of any General Motors product. The achievement of creating solid comfort in a truck that is capable of hauling 1½ tons is remarkable, and the superior han-

*Continued*



## POPULAR SCIENCE TEST RESULTS

### TEST RESULTS

	Chevrolet C2500 Fletside	Dodge D250 Sweptline	Ford F-150 Supercab
Acceleration (sec.)			
0-30 mph unloaded	3.5	3.8	4.0
0-30 mph loaded*	4.2	4.8	5.4
0-60 mph unloaded	10.5	11.2	11.9
0-60 mph loaded*	13.9	15.5	16.7
Brake test, 60-0 mph			
Stopping distance (ft.)			
wet unloaded	187	182	171
dry unloaded	174	173	157
dry loaded*	188	195	186
Pedal pressure, cold			
0.75-g. stop (lbs.)	20	36	30
Pedal pressure, hot			
0.75-g. stop (lbs.)	24	44	33
600-foot slalom (mph)	42.3	37.6	37.5
Double lane change (mph)	50.6	48.4	48.4
Interior noise (dBA)			
At idle	50	50	49
At 60 mph	66	71	69
EPA FUEL MILEAGE (mpg)			
Highway	20	13	18
City	14	11	14

\* One-ton payload

## Dimensions and specs

### DIMENSIONS (in.)

Wheelbase	131.5	131	138.8
Overall length	212.9	210.8	216.1
Overall width	76.4	79.5	79.0
Overall height	73.0	73.0	72.1

### SPECIFICATIONS (as tested)

Engine type	V8	V8	V8
Displacement (cu. in./liters)	350/5.7	360/5.9	302/5.0
Compression ratio	9.3:1	8.25:1	9.0:1
Induction	EFI	EFI	EFI
Net horsepower @ rpm	210 @ 4,000	190 @ 4,000	185 @ 3,800
Net torque (lb.-ft.) @ rpm	300 @ 2,800	295 @ 2,000	270 @ 2,400
Transmission	4-speed automatic	3-speed automatic	4-speed automatic
Final drive ratio	2.394:1	4.10:1	n.a.*
Steering	Power assist recirculating ball	Power assist recirculating ball	Power assist recirculating ball
Turn diameter (ft.)	46.5	47.0	46.9
Front suspension	Independent control arms stabilizer bar	Independent control arms, coil springs, stabilizer bar	Independent, swing axle, coil springs, stabilizer bar
Rear suspension	Live axle with semi-elliptical leaf springs	Live axle with semi-elliptical leaf springs	Live axle with semi-elliptical leaf springs, stabilizer bar
Brakes	Disc, rear anti-lock drum	Disc, rear anti-lock drum	Disc, rear anti-lock drum
Curb weight (lbs.)	4,496	4,273	4,567
F/R weight distribution (%)	55/45	60/40	55/45
Fuel tank (gal.)	34	22	35
Cargo box size (in.)	97.6x63.5	98.0x70.0	82.0x70.0
Base price	\$11,143	\$11,600	\$11,923
Price as tested	\$16,456 <sup>1</sup>	\$13,561 <sup>2</sup>	\$16,847 <sup>3</sup>

\* Not available

Major options (over \$100): <sup>1</sup> Preferred equipment group \$2,146, 4-speed automatic transmission \$795, 5.7-liter V8 engine \$755, H.D. trailing \$399, operating convenience package \$344, two-tone paint \$243; <sup>2</sup> A/C \$781, 5.9-liter V8 engine \$755, automatic transmission \$625, optional tires \$300, 8510 GVW option \$300, rear bumper \$200; <sup>3</sup> preferred equipment group \$1,051, automatic transmission \$796, A/C \$787, 5-liter V8 engine \$556, captain's chairs \$470, power windows, door locks \$344, deluxe two-tone paint \$267, chrome rear-step bumper \$226, handling package \$155

ding is sure to reduce driver fatigue.

The Ford F-series runs a close second, and with the larger V8 option it likely would have beat the Chevy in fuel economy as well as power. That's due to the port injection-fuel system, which offers real benefits. I also prefer the straightforward interior of the Ford.

The third-place Dodge has some advantages over the other two trucks in terms of price, simplicity, and potential durability. These are all important factors, particularly if the goal is just getting work done. Still, the chassis is long overdue for the kind of reengineering Chevrolet and Ford have put into their truck lines in recent years—engineering that adds comfort and detailing without compromising durability. **PS**

## The all-American pickup

The Sherman household could not get by without a pickup truck of some sort, though we only occasionally press our compact truck into service hauling wood, carting furniture, or towing the boat. The rest of the time we do what millions of other light-truck owners do: We use our pickup as a second family car.

In other words, handling, ride, and creature comforts, like climate-control and stereo systems, are every bit as important as a pickup's ability to shoulder a load.

All three American-made trucks passed our payload-carrying tests easily. But when we compared them unloaded in handling, braking, acceleration, and over-the-road driving, there were distinct differences.

The Dodge Ram is the veteran of the group. This elder statesman of the pickup world had trouble keeping pace when asked to perform like an automobile. Heavy-duty rear springs ruined the ride quality and caused the inside rear tire to spin fruitlessly during tight cornering. The big Ram was also a handful on the open road. The steering felt insensitive on center and heavily laced with friction everywhere else; this is a truck you have to herd rather than drive down the interstate. I wouldn't hesitate to recommend the Dodge for pure pickup duty, but those who need a combination car-truck should shop elsewhere.

The full-sized Ford is more comfortable than many new cars on the market, so it's easy to see why 588,000 customers selected this truck during the 1988 model year. The longer wheelbase that comes with Ford's Supercab may be beneficial in absorbing bumps, but it didn't help this contender wiggle its way through the cones in our handling tests. The Ford was annoyingly slow to answer helm commands.

While the Chevy C-series isn't as popular as Ford's big truck, it is the best seller in GM's lineup. It's also my pick of the three models in this group. I prefer the full-sized Chevy because it is clearly more carlike in day-to-day use than either the Dodge or Ford. The steering is quick and responsive, the grip at the limit of adhesion is impressive, and the V8 with throttle-body fuel injection delivers enough punch to keep up with the car crowd. If you need a truck this big (I personally don't), this is the one to get.—Don Sherman

## Parts and service

### PART PRICES (manufacturer's suggested retail)

Brake pads, front	\$ 32	\$ 61	\$ 47
Brake pads/linings, rear	49	105	64
Front shock/strut insert	39	17	21
Alternator	124	164	233
Fuel pump	35	221	194*
Ignition module	54	300	59
Grille	97	116	78
Front bumper	207	128	222
Windshield	375	227	391
Taillight lens	24	29	44

\* Electric

## PS serviceability ratings

Checking oil level	5	5	5
Checking coolant level	5	5	5
Adding oil	5	5	5
Changing oil filter	5	5	5
Changing spark plugs	5	5	5
Changing belts	3	4	4
Changing radiator hoses	4	4	4
Changing heater hoses	4	4	4
Checking fuses	5	5	5
Spare-tire access	3	3	3

(Ease of service: 5 = excellent, 1 = poor)



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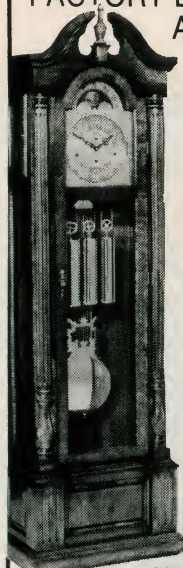
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# Looking Back...

Sampling a century of POPULAR SCIENCE

## 100 YEARS AGO FEBRUARY 1889

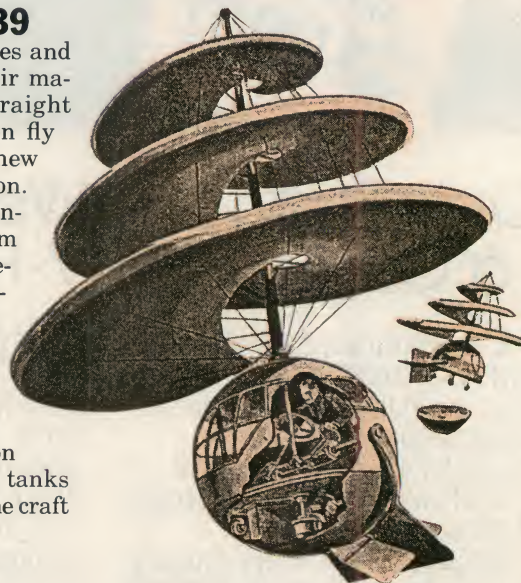
"Late in 1888 there was brought into the laboratory of the United States Fish Commission a male specimen of the lady crab (*Platyonychus ocellatus*), which was placed in an aquarium with a female crab of the same species. He was seen to rise upon the third and fourth pair of legs and slowly gyrate, wheeling in circles in the sand. His movements and attitude were the cause of much merriment on the part of the spectators. There are few, if any, performances of this kind on record by invertebrates."



## 50 YEARS AGO FEBRUARY 1939

"Whirring gyroplanes and amazing wingless air machines that soar straight up, hover motionless, and even fly backward, may soon open up a new chapter in the history of aviation. Spurred on by a grant from Congress, production is sure to boom soon. The first machines to be developed will probably be gyroplanes, the fantastic 'flying windmill' type of aircraft."

A California inventor proposed a helicopter with a gas-filled corkscrew "wing." In case of engine failure, a lower section containing the motor and fuel tanks could be dropped away, leaving the craft to float gently to Earth.



## 25 YEARS AGO FEBRUARY 1964

The new nuclear attack submarine *Thresher* was performing a test dive during its sea trials in the North Atlantic. "Suddenly, something broke, filling a compartment with sea water in seconds. Propulsion died, most likely due to a shorted-out power circuit. *Thresher* began to slide down, past its test depth, faster and faster. Then, starting with a small break around her middle, the ship cracked like an egg." The deep-diving craft *Trieste* eventually retrieved twisted remnants of the *Thresher* from their resting place under 8,000 feet of water.







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## What's News



### Stealth at last

If the picture above seems familiar, look at pages 46 and 47 in the July 1988 issue of POPULAR SCIENCE. The painting we had made of the B-2 bomber at that time, based entirely on our best guesses and the opinions of independent experts in aerodynamics and electronics, was strikingly similar to the picture on this page.

The photo in question came from the recent public rollout of the B-2 prototype at Northrop's Palmdale, Calif., plant. It was the first time anyone outside of Northrop or the military had seen the mysterious stealth bomber. Nevertheless, it turns out that the information we published regarding the B-2 was remarkably accurate in most areas, with only one miss.

Our story predicted that the bomber would have four engines, each with 17,000 pounds of thrust. It turns out that each of the four engines has 19,000 pounds. We estimated the wingspan would be 130 to 140 feet; actual wingspan is 172 feet. We said the plane would be subsonic, which it is, and we said its range would be in the 5,000-mile area. Actual range, we now hear, is in the 6,000-mile vicinity. We estimated the weight to be between 240,000 and 275,000 pounds. The actual weight can be surmised from an odd fact: The plane—at least this version—is apparently equipped with a standard Boeing 757 or 767 landing gear, which, experts say, probably means the plane weighs in the same neighborhood as these planes, or between 220,000 and 330,000 pounds.

Our one miss involved the outer surface. Many experts we spoke to predicted that the skin would be faceted—made up of many flat segments. That construction would help cut radar cross section and add to the stealthi-

ness of the beast. The new F-117A stealth fighter [January] has facets of this kind. But the prototype plane that was displayed does not. As the picture above shows, it has a smoothly contoured skin.

The top of the wing is painted a dull blue-gray color. The leading edge, however, including the first few feet of the top of the wing, is covered by a shiny black skin. This apparently is part of the complex structure designed to absorb rather than reflect radar signals.

*Aviation Week* reported that large rectangular sections appeared on each side of the nose wheel and that these might be radomes covering the flat-plate radar. Because the B-2 carries its weapons payload internally—necessary to hold down radar signature—the plane has what one observer called a “very pregnant” look.

The rollout ceremony was different from the usual. Generally, the U.S. Air Force makes significant public-relations mileage out of such events, with thousands of guests, scads of bunting, and lots of speeches. But relatively few guests were invited to the stealth debut. Most surprising, the plane was rolled directly out of the plant and stayed near the door while guests were kept at a distance behind a line of Air Force security police—many with guard dogs. The guards stayed between guests and plane for the entire ceremony.

This approach shielded from view the rear of the wing where, presumably, the top-secret control surfaces are located. Also hidden was the engine exhaust on top of the wing toward the trailing edge. It was clear, however, that the plane has no vertical tail surfaces.

Because the plane has such a small radar cross section, it reportedly does not carry the complex electronic coun-

termeasures needed by the B-1B. And that “is a nonexistent issue as far as the B-2 is concerned,” said one Air Force official.

The rollout reportedly was held at this time because the plane is approaching the flight-testing stage and the Air Force decided to go public rather than limit testing to remote sites during the hours of darkness. “We plan to fly this plane during the daytime, and a lot of people are going to see it,” said Secretary of the Air Force Edward C. Aldridge Jr. “Moreover, people have accused us of being too secretive.” Many would agree. Although the project’s existence was announced in August 1980 during the Carter administration, the plane had never been seen and little detail had been revealed until the rollout.

The first test model is scheduled for taxi tests, and then its first flight to nearby Edwards Air Force Base early this year.

An interesting sidelight was revealed during the rollout ceremonies. The flying-wing concept was pioneered in the 1940s and ’50s by Jack Northrop, founder of Northrop Corp. But he was frustrated that he couldn’t sell the Air Force on the design’s merits. However in 1981, shortly before Jack Northrop died, the Air Force paid him an unusual honor, said Northrop chairman Thomas Jones. Officials, said Jones, held a “private, specially arranged briefing” for Northrop, and told him that the flying wing would be used in the top-secret bomber.

*C. B. Filmore*  
Editor-in-Chief





The X-31 supermaneuverable fighter will demonstrate the feasibility of “post-stall” flight: that is, controlled flight at high angles of attack—the angle of a wing’s chord to the relative wind. This extreme nose-up condition causes conventional airplanes to stall and fall into a tailspin. The tremendous agility made possible by operating in this post-stall flight regime will permit rapid fuselage-pointing and target-acquisition during the course of air-to-air combat—the keys to victory in future dogfights.

To date, the aerodynamics of post-stall flight remain relatively unknown. Flight tests of the X-31 will do much to advance aerodynamicists’ understanding of the subject. When a plane climbs into a beyond-stall angle of attack, the airstream over its wings rapidly changes from a fully attached, lift-producing flow to a fully detached, zero-lift flow, explains Capt. Hank Helin, program manager for aerospace science at the Air Force Office of Scientific Research, Washington, D.C. According to Helin, the phenomenon occurs

as follows: In this nose-up attitude, extremely low air pressures on the dorsal wing surface cause a complex system of vortices to form in the viscous boundary layer of air adhering to the wing surface. This vorticity accumulates and then rolls up into large dynamic stall vortices, which convect off aircraft surfaces. Vortex shedding can place large instantaneous loads and moments on the airframe that must be managed. Complex supercomputer simulations now allow aerodynamicists to predict these events with sufficient accuracy so they can design the X-31 to be strong enough to resist the loads. The calculations also permit the plane’s computerized-control system to be programmed to accommodate the transient moments so the vortex shedding doesn’t produce loss of control.

A thrust-vectoring system (1) will permit the X-31 to retain directional and attitudinal control even when its flight-control surfaces become inoperative due to post-stall





# X-31

## *How they're inventing a radical new way to fly*

Victory in dogfights goes to the pilot who jockeys his fighter into position and launches first. As missiles grow smarter, even greater agility will be required. That means pilots will fly at angles of attack that normally cause an airplane to stall and fall into a tailspin. To explore "post-stall" flight, an experimental aircraft called the X-31 supermaneuverable fighter is being built by the United States and West Germany. It will pioneer this wild way to fly.

conditions. The plane's flight controls will use the thrust-vectoring system to power the aircraft through the "rough" spots of post-stall maneuvers by brute force. The thrust-vectoring system consists of three paddles or vanes that can move into the exhaust stream to deflect it to one side or the other. The vanes can deflect up through 10 degrees in both the pitch and yaw orientations.

The X-31's flight control surfaces include a forward canard that can rotate 90 degrees (2), wing-tip elevons (3), and trailing-edge flaperons (4). These subsystems are integrated into the plane's computerized flight controls.

Several off-the-shelf components were used: the engine is the 12,000-pound-thrust General Electric F404 turbine, the same power plant used in the F-18 fighter. The X-31's canopy, ejection seat, and instrument panel also come from the F-18. Landing gear comes from the F-16 fighter. The flight computer is adapted from a Honeywell computer used in the Air Force's High Technology Testbed.

By **JIM SCHEFTER**

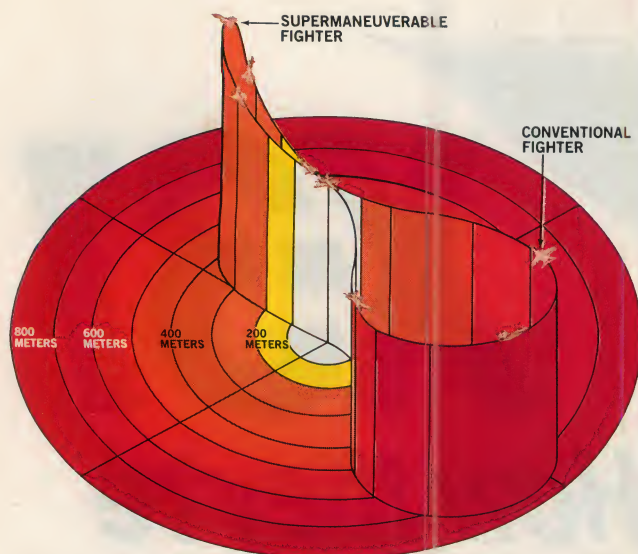
*Illustrations by Mark McCandlish*

**W**hen he spotted two enemy fighters breaking through the haze blanketing the Baltic seacoast, the NATO fighter pilot wasn't surprised. Though his plane was radar equipped, the veteran pilot had never stopped scanning the sky for intruders. Since the alert, "electronic fog" produced by radar jammers on both sides of the German border had wreaked havoc on his plane's radar set. Now at close range his cockpit radar display showed a pair of ominous red blips starting to wheel in his direction.

With a deft movement of the stick, the missile-laden fighter banked left on cranked-delta wings. The pilot keyed

*Continued*





Shown here is the minimum-radius turn of a conventional aircraft compared with that of the X-31 fighter. Post-stall flying capabilities enable the X-31 to come about quicker than conventional planes, so it would launch a missile sooner.

his mike, calling: "Medusa Control, this is Cobra Picket Three. Two bandits heading two-six-five. Range: six miles. Engaging now. Repeat..." The NATO pilot now flicked on his target-acquisition radar.

Closing one mile every three seconds, there's no time to waste. He has just one thought now: "Put your nose on target long enough to get the missiles to lock on." Precision isn't necessary, the veteran reminds himself. "Just get the nose pointed in the vicinity of the bandits, and the missiles' seeker heads will do the rest." With planes jinking wildly all over the sky, the hard part is to get in the vicinity.

## Deadly game

The opposing jets start to converge in ever-tightening arcs. Suddenly the enemy pilots fling their machines into climbing turns, each seeking to swing his jet through its spiral fast enough to bring his weapons to bear upon the lone defender. This deadly game has a name: Kill before counter-launch.

But the veteran NATO pilot has it timed beautifully. He raises the plane's nose into a high-angle-of-attack climb, and it starts to enter what should be a curving loop. Just when it should be a sitting duck—with momentum sending it along a predictable path while the flight controls get mushy from the onset of a stall—the situation changes.

Rolling and yawing with incredible precision as flames spurt obliquely from the tail exhaust, the fighter's nose tracks rapidly away from the line of flight. For a moment the pilot's ship flies sideways, then backwards, finally whipping around with its tail slewing off to the side like a car doing doughnuts on a snow-covered road. Amazingly, the entire instant about-face is performed under perfect control. His missiles lock on to the targets with a gratifying buzz.

Taken aback by the abrupt move, the enemy pilots maneuver frantically to escape, but the NATO plane sticks to them like superglue. With missile-lock-on warning alarms screaming in their ears, they both know that the dogfight is over. First one and then the other jet streaks to safety across the border. Following orders, the NATO pilot breaks off the attack and returns to station.

Even as they flee, the enemy pilots can't believe what

they have just seen. The NATO fighter's nose had pointed in one direction even as the plane went in another. Airplanes just don't fly that way.

Not yet, they don't. But the rules of flight dynamics are about to change.

Those rules, which determine an airplane's flight envelope—which maneuvers are safe and which aren't—haven't changed much since man first took wing. And one of the first rules a pilot learns is: Don't climb too steeply! The result is an aerodynamic stall, the loss of lift that occurs when a wing's angle of attack into the oncoming air is too steep to permit air to flow over the top surface and thus produce lift. The resulting stall often leads to an uncontrolled downward tailspin from which the pilot may not recover.

## Beyond stall

But when the X-31 supermaneuverable fighter, a new experimental aircraft now being built by Rockwell International and Messerschmitt-Bölkow-Blohm GmbH (MBB), takes to the air this November, its test pilots will stall their wings on purpose. Instead of spinning out of control, however, they are expected to demonstrate heretofore impossible aerial maneuvers.

These attempts to expand the envelope into the treacherous and complex regime of "post-stall" flight may have important effects on future fighter design. Experts say that a fighter capable of breaking the stall-barrier will have a decided advantage over conventional adversaries. The lightning-quick agility afforded by post-stall flight would allow a fighter to aim and launch first—the key to victory in tomorrow's dogfight. X-31 pilots may find at their fingertips the kind of never-before-seen aerial maneuverability that will give old dogfighters new dreams and enemy fighter pilots nightmares.

The \$80-million X-31 development program is funded jointly by the U.S. Defense Advanced Research Projects Agency (DARPA) and the West German Ministry of Defense, with the U.S. Naval Air Systems Command acting as the manager. As the first NATO cooperative venture to be launched under the Nunn-Quayle Research and Development Initiative, major aircraft components are being fabricated in MBB facilities near Munich, and in Rockwell's Palmdale, Calif., plant, where two X-31s are to be assembled and flown.

"What we're doing is called post-stall maneuvering," says Rockwell Program Manager Mike Robinson. "Instead of losing control when the aircraft stalls, we're using thrust vectoring to penetrate an area where no one has been flying."

In practical terms the X-31's unique movable tail vanes will channel thrust from its single jet engine, angling it in one direction or another to replace the directional and attitudinal control lost by the stalled flight surfaces. The aircraft will not only keep flying, it will allow the pilot to maneuver through twists and turns that would make a snake dizzy.

The development program was in fact once called SNAKE—for super-normal attitude kinetic enhancement. Then cooler heads prevailed and that jawbreaking acronym faded. It's now called the Enhanced Fighter Maneuverability program. But the supermaneuvering capabilities—also called Herbst Maneuvers—that X-31 pilots hope to demonstrate remain.

## Fire first

Dr. Wolfgang B. Herbst is MBB's X-31 program manager. The radical maneuvers planned for the X-31 had their origin in his observations of air combat and computer simulations of dogfights. "We were trying to acquire targets





A model of the X-31 undergoes wind-tunnel testing at NASA-Langley (Va.). The design was tested in a "water tunnel" used to evaluate models of ship hulls—the Hydronautics Ship Model Basin at Tracor Hydrodynamics in Laurel, Md.

[to lock on] from any position," he recalls, "but we realized that if both opponents are equipped with sophisticated weapons, head-on encounters will dominate most conflicts.

"It's a tough situation," Herbst continues. "Both planes are turning into each other head-on to get a firing solution. So the name of the game is to fire your weapon a little quicker than your opponent can. But the only way to put your weapon into position faster is to cut corners. And that's nothing more than flying a smaller radius of turn."

What sounds simple in theory is much more complex in practice. With beyond-visual range missiles that can track and kill an enemy aircraft long before either pilot sees the other, some designers argue that the days of dogfighting are done. But Herbst and most NATO air commanders feel otherwise. "In Europe, by the time you launch a sortie you're in close-air-combat," Herbst tells me. "And even if both sides are equipped with beyond-visual range missiles, those long spears will still require the pilot to launch first. You'll still want to maneuver yourself into a position in space, time, and energy that gives you a better chance to kill your opponent before he kills you. And if you want that advantage with your long spear, you've still got to move around fast. That means maneuverability."

### Cutting corners

The most maneuverable of today's fighters, the F-18, for instance, can use up to three miles of sky in a supersonic turn. Even that radius will put it inside the turns of less-sprightly fighters often enough to give its pilot the first shot. But it's still too large, particularly when the odds may be one F-18 against two or three bad guys.

The problem is that tighter turns are limited by an aircraft's "corner speed," the Mach number that gives the maximum rate of turn. Exceeding the corner speed subjects pilots to excessive g forces, can rip the wings off, or cause other less-than-desirable effects.

"So the question came up, how can we turn the aircraft in a smaller radius?" says Herbst. "The only way is to exceed the stall limits of the aircraft."

As stated previously, an aircraft stalls when its high angle of attack causes airflow over its flight surfaces (wings, ailerons, and rudder) to be too low. Controls get mushy, and the aircraft loses its grip on the air and falls.

In the X-31, however, control never goes away. When the supermaneuverable fighter stalls, computer-controlled thrust vectoring takes over. The aircraft will have a trio of curved paddles extending beyond its jet engine nozzle. In normal flight, the paddles simply channel the hot exhaust gases in a straight line. But when it's time to make like a snake, the computer moves one or more paddles into the exhaust stream and deflects it at an angle. The vectored thrust will then send the X-31 careening through "impossible" maneuvers.

"Hey, let's have a little magic," says Ken Dyson, Rockwell's chief of flight test, as Mike Robinson lifts a model of the X-31 off the table to show me a typical post-stall maneuver. Dyson will make the X-31's first flight and has been flying post-stall maneuvers in flight simulators since the program was conceived in 1982. From the pilot's point of view, he says, the maneuvers are straightforward as long as he can see the enemy.

That's his opinion. From my observations of Robinson's model, the X-31's maneuvers will be anything but straightforward. From level flight, Robinson pitches the model up into a stall-inducing climb. "This is where thrust vectoring takes over," he says.

Continuing the model's trajectory into a loop, he yaws the plane to the right. Suddenly the model is going sideways while its nose is pointing right. At that point the pilot can slice the nose through the sky, pointing it in any direction, he explains. "You have the other airplane as a reference and you're going for him," Dyson interjects. "You can just pull your nose around to point at the guy as you try to cut off his trajectory."

If the simulations, calculations, and wind-tunnel tests

*Continued*

**Future dogfight:** Shown on the following pages is an example of an encounter between several supermaneuverable (SM) and conventional fighter aircraft. (The aircraft are shown in different stages of the same maneuver.) To get into firing position, an SM fighter pulls nose up into a high-angle-of-attack attitude that pilots call a hammerhead. From this near-vertical position, an SM fighter performs a till-now impossible maneuver in which its nose rapidly slews off to the side until the pilot's sights bear on the target. Before his conventional adversary can position himself to return fire, the SM fighter launches a missile.











are correct, the airplane will remain perfectly stable during the few moments it takes for the jet thrust to propel the X-31 off in the direction in which its nose is pointing.

Dyson notes that during that short interval the aircraft's rudders are useless. All control is with the stick. The on-board computer reads the pilot's stick movements, then signals the thrust-vectoring paddles to move into and out of the exhaust stream.

### Pilot problems

"There's going to be some initial confusion for pilots," Herbst notes. "He can be flying backward and looking forward. The g forces he feels are going to be different—perhaps stronger and much shorter in duration—than he's accustomed to. It's like skiing, except you lean away from the mountain instead of toward it."

"There is some learning needed for a pilot to get the maneuvers down," Dyson agrees, "but not much." "We've gone to a lot of effort to make the uniqueness of the maneuvers transparent to the pilot," says Sid Powers, Rockwell's chief engineer. But he acknowledges that the computer will do the real work.

"In a high angle of attack, full stick and rudder deflection usually sets up a spin," Powers says. "If our control system is working properly, the X-31 won't spin at all." A typical jet fighter will stall with the nose up about 35 degrees, unless it has the speed to carry it into a loop. The X-31 will handle angles of attack between 50 and 90 degrees.

"It might take many test flights to reach that point while we get all the systems set up," Powers points out. "There's many a surprise between the wind tunnel and flight test."

The X-31's unique flight control laws and initial computer programming for the plane's fly-by-wire control system are being handled by MBB. "The flight rules beyond stall are very different," Herbst tells me. "When you increase the angle of attack, you get less lift. But we want more lift, so the computer has to compensate with thrust vectoring.

"To point the nose at low angles of attack, you just use the stick to bank or to roll. At higher angles, you have to roll and yaw [with the rudder] at the same time for a coordinated maneuver," he explains. By the time you get to ninety degrees, or straight up, any maneuver is a yaw, but the rudder is dead. However, with the computer taking increasing control as angles increase and the thrust-vectoring system compensating for lost lift, the nose will respond to stick input.

"The pilot simply can't do everything that's needed," Herbst says. "The computer has to do it for him. You can't fly post-stall maneuvers with a mechanical control system. It has to be replaced by mathematical algorithms run by a computer."

### Agile airframe

The designers of the X-31 have made extensive use of the technology bases generated by two supermaneuverability research programs conducted several years ago: Rockwell's HIMAT, for Highly Maneuverable Aircraft Technology testbed, and MBB's TKF-90 program. HIMAT is a subscale remotely piloted research vehicle that was carried aloft by a specially equipped B-52 bomber and then

released to perform supermaneuverability tests. The unmanned jet could outturn any manned fighter flying.

The X-31 itself is a shapely bird, configured for supersonic maneuvering. But during flight tests, it will be held to Mach 0.9.

Rockwell-built canards mounted just forward of the canopy will deflect 90 degrees during post-stall maneuvers, as will the full-length elevons on the space-shuttle-shaped wings, which are being built from lightweight carbon-fiber composites by MBB.

"MBB has done a lot of the basic work on high angle-of-attack wings," Robinson says. "Their function is dominated by the planform shapes." Rockwell designers took MBB's planform, which it had developed for years, and then did additional computer work to refine its shape. "Wind-tunnel tests exceeded all of our performance expectations," Robinson says. "It's a very high-performance wing."

The X-31's planform shapes are ideal for maneuvering supersonic aircraft, Robinson explains: "There's lots of sweep to get behind the supersonic shock wave, then it cranks out, or unsweeps, to give more stability and control. We saved at least eight months of development time by using the MBB planform."

To increase strength and reduce weight, the West German company is using carbon-fiber composites for the wing and for the thrust-vectoring paddles. Rockwell also is using advanced composites for the canards, vertical surfaces, and some access doors.

### Planes the old-fashioned way

Along the way the companies looked for ways to keep costs low. "We took it as a challenge to build a low-cost demonstrator," Robinson says. "For example, we're using thrust-vectoring paddles instead of building an all-new engine nozzle." In addition, Rockwell and MBB opted for previously qualified off-the-shelf components wherever possible to keep costs down, he adds.

The companies also see significant cost savings in the X-31's short development time, just 15 months from signing the contract to the first flight. "We're not sticking to the conventional rules of either company," Herbst tells me. "We're shortening the process,

doing handwritten changes, using telephone calls instead of the typical way of writing, reviewing, and approving. We're going back to the way airplanes used to be built.

"We're also taking some risks. Aircraft development these days has deteriorated. Everybody wants to eliminate risk, do more analysis, do more testing. We're accepting a certain level of risk to save time and cost. For instance, we're not doing any major wing testing, only in some critical areas, but no major static testing."

More than 600 flight tests spread over two years—first in the Mojave Desert north of Los Angeles, then at the Navy's Patuxent River Naval Air Station in Maryland—are planned for the X-31. When the program ends, Robinson says, it should bequeath a wealth of data to designers of future fighters.

"Anybody who wants a new fighter will have the option of adding this technology," Herbst says. "Still, it's a high-risk program. But if you don't accept risk, you're not going to achieve anything without spending a lot more money. Risk isn't bad. It's good."

**“The name of the game is to fire your weapon a little quicker than your opponent can”**



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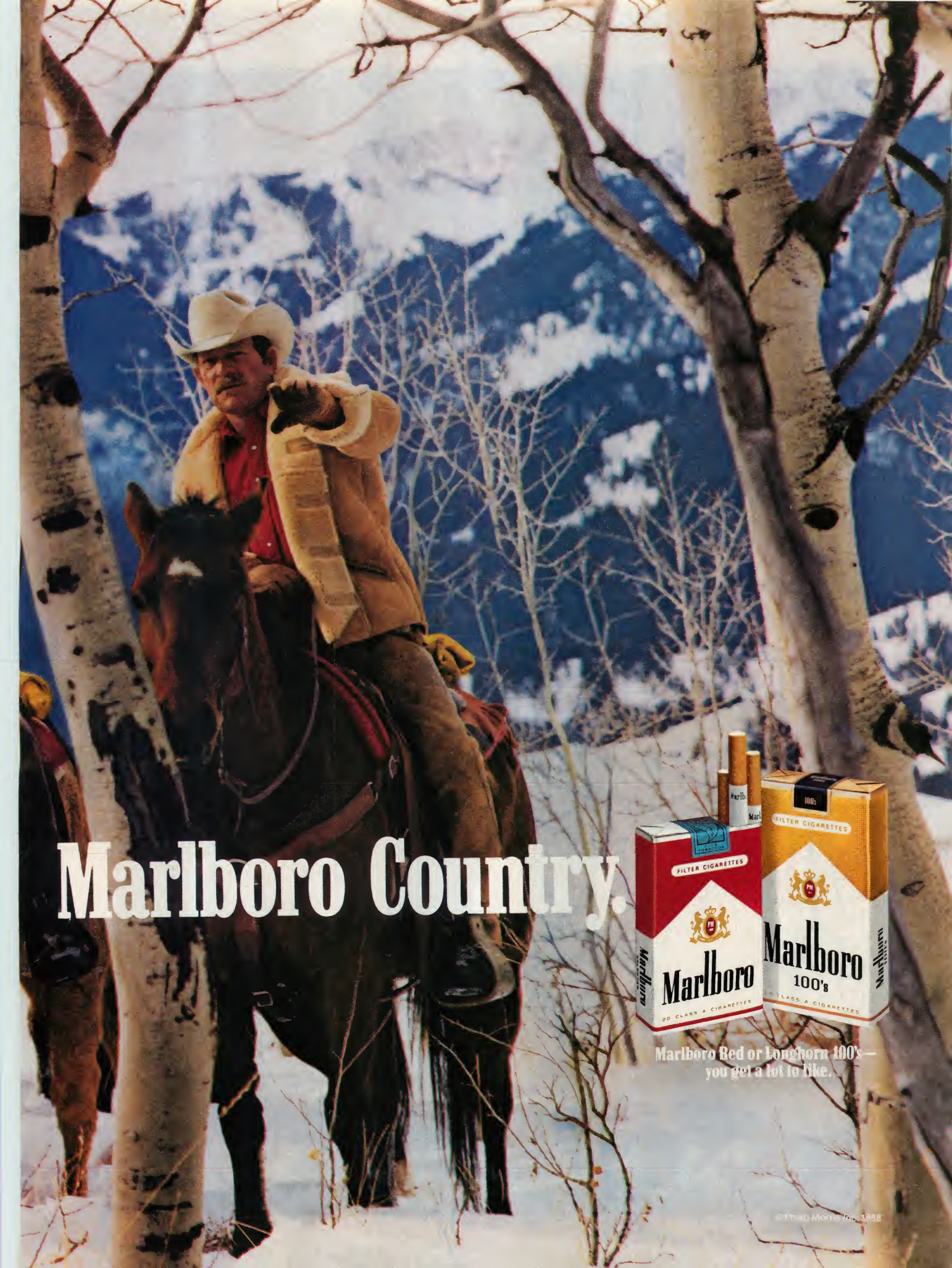
A man wearing a light-colored cowboy hat and a brown shearling jacket is riding a light-colored horse. He is looking towards the right. In the background, there are several birch trees with white bark and black lenticels. The ground is covered in snow, and the sky is a clear, deep blue. The overall scene is a winter landscape.

# Come to

SURGEON GENERAL'S WARNING: Smoking Causes Lung Cancer, Heart Disease, Emphysema, And May Complicate Pregnancy.

16 mg "tar," 1.0 mg nicotine  
av. per cigarette, FTC Report Feb. '85





# Marlboro Country.



Marlboro Red or Longhorn 100's —  
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PHOTO BY MAY AGUIRERA-HELLWEG



Researchers are modeling a new breed of superpowerful computers after the ultimate processor: the human brain. Called neural-network computers, these machines could master such tasks as speech and handwriting recognition, target identification, and robot vision—tasks that prove extremely difficult for traditional computers.

# BRAIN- STYLE COMPUTERS

By NAOMI J. FREUNDLICH

Physicist John Hopfield looked to the brain's vast network of neurons as a model for computing and mathematically calculated how individual computing units or neurons can act collectively to store and process information.

I walked into the semi-circular lecture hall at Columbia University and searched for a seat within the crowded tiered gallery. An excited buzz petered off to a few coughs and rustling paper as a young man wearing circular wire-rimmed glasses walked toward the lectern carrying a portable stereo tape player under his arm. Dressed in a tweed jacket and corduroys, he looked like an Ivy League student about to play us some of his favorite rock tunes. But instead, when he pushed the "on" button, a string of garbled baby talk—more specifically, baby-computer talk—came flooding out. At first unintelligible, really just bursts of sounds, the child-robot voice repeated the string over and over until it became ten distinct words.

"This is a recording of a computer that taught itself to pronounce English text overnight," said Terrence Sejnowski, a biophysicist at Johns Hopkins University. A jubilant crowd broke into animated applause. Sejnowski had just demonstrated a "learning" computer, one of the first of a radically new kind of artificial-intelligence machine.

Called neural networks, these computers are loosely modeled after the interconnected web of neurons, or nerve cells, in the brain. They represent a dramatic change in the way scientists are thinking about artificial intelligence—a leaning toward a more literal interpretation of how the brain functions. The reason: Although some of today's computers are extremely powerful processors that can crunch numbers at phenomenal speeds, they fail at tasks a child does with ease—recognizing faces, learning to speak and walk, or reading printed text. According to one expert, the visual system of one human being can do more image processing than all the supercomputers in the world put together. These kinds of tasks require an enormous number of rules and instructions embodying every possible variable. Neural networks do not require this kind of programming, but rather, like humans, they seem to learn by experience.

For the military, this means target-recognition systems, self-navigating tanks, and even smart missiles that chase targets. For the business world, neural networks promise handwriting- and face-recognition systems and computer loan officers and bond traders. And for the manufacturing sector, quality-control vision systems and robot control are just two goals.

Interest in neural networks has grown exponentially. A recent meeting in San Diego brought 2,000 participants. More than 100 companies are working on neural networks, including several small start-ups that have begun marketing neural-network software and peripherals. Some computer giants, such as IBM, AT&T, Texas Instruments, Nippon Electric Co., and Fujitsu, are also going full ahead with research. And the Defense Advanced Research Projects Agency (or DARPA) released a study last year that recommended neural-network funding of \$400 million over eight years. It would be one of the largest programs ever undertaken by the agency.

Ever since the early days of computer science, the brain has been a model for emerging machines. But compared

*Continued*



with the brain, today's computers are little more than glorified calculators. The reason: A computer has a single processor operating on programmed instructions. Each task is divided into many tiny steps that are performed quickly, one at a time. This pipeline approach leaves computers vulnerable to a condition commonly found on California freeways: One stalled car—one unsolvable step—can back up traffic indefinitely. The brain, in contrast, is made up of billions of neurons, or nerve cells, each connected to thousands of others. A specific task enlists the activity of whole fields of neurons; the communication pathways among them lead to solutions.

The excitement over neural networks is not new and neither are the "brain makers." Warren S. McCulloch, a psychiatrist at the Universities of Illinois and Chicago, and his student Walter H. Pitts began studying neurons as logic devices in the early 1940s. They wrote an article outlining how neurons communicate with each other electrochemically: A neuron receives inputs from surrounding cells. If the sum of the inputs is positive and above a certain preset threshold, the neuron will fire. Suppose, for example, that a neuron has a threshold of two and has two connections, A and B. The neuron will be on only if both A and B are on. This is called a logical "and" operation. Another logic operation called the "inclusive or" is achieved by setting the threshold at one: If either A or B is on, the neuron is on. If both A and B are on, then the neuron is also on.

In 1958 Cornell University psychologist Frank Rosenblatt used hundreds of these artificial "neurons" to develop a two-layer pattern-learning network called the perceptron. The key to Rosenblatt's system was that it learned. In the brain, learning occurs predominantly by modification of the connections between neurons. Simply put, if two neurons are active at once and they're connected, then the synapses (connections) between them will get stronger. This learning rule is called Hebb's rule and was the basis for learning in the perceptron. Using Hebb's



rule the network appears to "learn by experience" because connections that are used often are reinforced. The electronic analog of a synapse is a resistor and in the perceptron resistors controlled the amount of current that flowed between transistor circuits.

Other simple networks were also built at this time. Bernard Widrow, an electrical engineer at Stanford University, developed a machine called Adaline (for adaptive linear neurons) that could translate speech, play blackjack, and predict weather for the San Francisco area better than any weatherman. The neural-network field was an active one until 1969.

In that year the Massachusetts Institute of Technology's Marvin Minsky and Seymour Papert—major forces in the rule-based AI field—wrote a book called *Perceptrons* that attacked the perceptron design as being "too simple to be serious." The main problem: The perceptron was a two-layer system—input led directly into output—and learning was limited. "What Rosenblatt and others wanted to do basically was to solve difficult problems with a knee-jerk reflex," says Sejnowski.

The other problem was that perceptrons were limited in the logic operations they could execute, and therefore they could only solve clearly definable problems—deciding between an L and a T for example. The reason: Perceptrons could not handle the third logic operation called the "exclusive or." This operation requires that the logic unit

Neural-network-based products are beginning to enter the marketplace. Robert Hecht-Nielsen (top), president of Hecht-Nielsen Neurocomputers, developed a specially wired plug-in board for PCs that speeds up neural-network simulations. Applications with the company's system include number-, aircraft-, and face-recognition systems. In the example above, the network is trained by having the numbers 1 to 10 written on a data-entry tablet in different styles of handwriting and configurations. When a user scrawls out a number—even upside down or backward—the computer gives the closest correct answer.



turn on if either A or B is on, but not if they both are.

According to Tom Schwartz, a neural-network consultant in Mountain View, Calif., technology constraints limited the success of perceptrons. "The idea of a multilayer perceptron was proposed by Rosenblatt, but without a good multilayer learning law you were limited in what you could do with neural nets." Minsky's book, combined with the perceptron's failure to achieve developers' expectations, squelched the neural-network boom. Computer scientists charged ahead with traditional artificial intelligence, such as expert systems.

## Underground connections

During the "dark ages" as some call the 15 years between the publication of Minsky's *Perceptrons* and the recent revival of neural networks, some die-hard "connectionists"—neural-network adherents—prevailed. One of them was physicist John J. Hopfield, who splits his time

between the California Institute of Technology and AT&T Bell Laboratories. A paper he wrote in 1982 described mathematically how neurons could act collectively to process and store information, comparing a problem's solution in a neural network with achieving the lowest energy state in physics. As an example, Hopfield demonstrated how a network could solve the "traveling salesman" problem—finding the shortest route through a group of cities—a problem that had long eluded conventional computers. This paper is credited with reinvigorating the neural-network field. "It took a lot of guts to publish that paper in 1982," says Schwartz. "Hopfield should be known as the fellow who brought neural nets back from the dead."

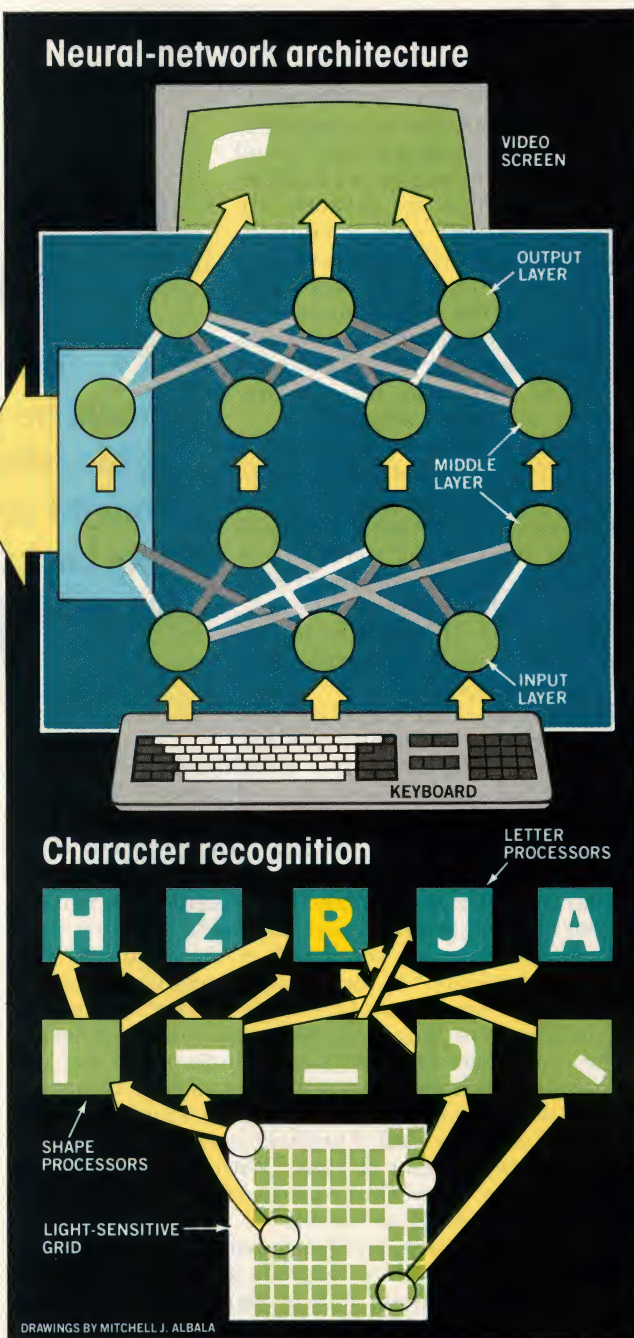
The resurgence of more-sophisticated neural networks was largely due to the availability of low-cost memory, greater computer power, and more-sophisticated learning laws. The most important of these learning laws is some-

*Continued*

The drawing (top right) shows the basic structure of a neural-network computer, while the bottom drawing illustrates a character-recognition application. The circles represent electronic processors organized into layers. For this example a keyboard is used for input signals and a video screen for the output. In robots the inputs might be optical sensors and the output would be movement of the robot. The processors are organized into layers: an input layer, an output layer, and a layer of processors sandwiched in between that actually learn from experience how to activate the correct output processors to give a correct answer. The different colored lines running from one layer of processors to the next represent signals that have voltages of different strengths. Regulated by different resistor values (see detail, at right), a signal coming into a processor can represent a strong or weak connection. In the detail, processor A weighs all incoming signals, sums them, and if the sum is above a preset threshold, produces an output signal. This output then becomes an input to processor B in the next layer.

A neural network is not programmed with rules and instructions, but can be trained by several methods. A computer being trained to identify objects, for example, would be shown a key via a camera. If it guesses "computer chip" instead, an operator can key in an error signal. This signal passes through the network, strengthening connections that lead to a correct answer—"key"—and weakening those that led to "computer chip." A small memory in each processor stores this information and helps establish the firing threshold.

In the character-recognition example, the neural network was trained by example to recognize letters. In practice, after the letter R is drawn on a data-entry tablet, a light-sensitive grid is placed over the letter, breaking it down into dark and light areas. If an area is light, the computer sends a signal to a specific processor in the layer of processors whose function is to recognize different shapes within letters. The shape processors in turn send signals that represent possible letters to the layer above. Because of the previous training, stronger signals are sent to letters that are most likely to contain a given shape. At the output layer, the processor receiving the strongest combination of signals activates the correct letter.





thing called back-propagation, illustrated dramatically by Sejnowski's NetTalk, which I heard at Columbia.

With NetTalk and subsequent neural networks, a third layer, called the hidden layer, is added to the two-layer network. This hidden layer is analogous to the brain's interneurons, which map out pathways between the sensory and motor neurons. NetTalk is a neural-network simulation with 300 processing units—representing neurons—and over 10,000 connections arranged in three layers. For the demonstration I heard, the initial training input was a 500-word text of a first-grader's conversation. The output layer consisted of units that encoded the 55 possible phonemes—discreet speech sounds—in the English language. The output units can drive a digital speech synthesizer that produces sounds from a string of phonemes. When NetTalk saw the letter N (in the word "can" for example) it randomly (and erroneously) activated a set of hidden layer units that signaled the output "ah." This output was then compared with a model: a correct letter-to-phoneme translation, to calculate the error mathematically. The learning rule, which is actually a mathematical formula, corrects this error by "apportioning the blame"—reducing the strengths of the connections between the hidden layer that corresponds to N and the output that corresponds to "ah." "At the beginning of NetTalk all the connection strengths are random, so the output that the network produces is random," says Sejnowski. "Very quickly as we change the weights to minimize error, the network starts picking up on the regular pattern. It distinguishes consonants and vowels, and can make finer distinctions according to particular ways of pronouncing individual letters."

Trained on 1,000 words, within a week NetTalk developed a 20,000-word dictionary. "The important point is that the network was not only able to memorize the training words, but it generalized. It was able to predict new words it had never seen before," says Sejnowski. "It's similar to how humans would generalize while reading 'Jabberwocky.'"

Generalizing is an important goal for neural networks. To illustrate this, Hopfield described a munition identification problem he worked on two summers ago in Fort Monmouth, N.J. "Let's say a battalion needs to identify an unexploded munition before it can be disarmed," he says. "Unfortunately there are 50,000 different kinds of hardware it might be. A traditional computer would make the identification using a treelike decision process," says Hopfield. "The first decision could be based on the length of the munition." But there's one problem: "It turns out the munition's nose is buried in the sand, and obviously a soldier can't go out and measure how long it is. Although you've got lots of information, there are always going to be pieces that you are not allowed to get. As a result you can't go through a treelike structure and make an identification."

Hopfield sees this kind of problem as approachable from a neural-network point of view. "With a neural net you could know ten out of thirty pieces of information about the munition and get an answer."

Besides generalizing, another important feature of neural networks is that they "degrade gracefully." The human brain is in a constant state of degradation—one night spent drinking alcohol consumes thousands of brain cells.

But because whole fields of neurons contribute to every task, the loss of a few is not noticeable. The same is true with neural networks. David Rumelhart, a psychologist and neural-network researcher at Stanford University, explains: "The behavior of the network is not determined by one little localized part, but in fact by the interactions of all the units in the network. If you delete one of the units, it's not terribly important. Deleting one of the components in a conventional computer will typically bring computation to a halt."

## Simulating networks

Although neural networks can be built from wires and transistors, according to Schwartz, "Ninety-nine percent of what people talk about in neural nets are really software simulations of neural nets run on conventional processors." Simulating a neural network means mathematically defining the nodes (processors) and weights (adaptive coefficients) assigned to it. "The processing that each element does is determined by a mathematical formula that defines the element's output signal as a function of whatever input signals have just arrived and the adaptive coefficients present in the local memory," explains

Robert Hecht-Nielsen, president of Hecht-Nielsen Neurocomputer Corp.

Some companies, such as Hecht-Nielsen Neurocomputer in San Diego, Synaptics Inc. in San Jose, Calif., and most recently Nippon Electric Co., are selling specially wired boards that link to conventional computers. The neural network is simulated on the board and then integrated via software to an IBM PC-type machine.

Other companies are providing commercial software simulations of neural networks. One of the most successful is Nestor, Inc., a Providence, R.I.,-based company that developed a software package that allows users to simulate circuits on desk-top computers. So far several job-specific neural networks have been developed. They include: a signature-verification system; a network that reads handwritten numbers on checks; one that helps screen mortgage loans; a network that identifies abnormal heart rates; and another

that can recognize 11 different aircraft, regardless of the observation angle.

Several military contractors including Bendix Aerospace, TRW, and the University of Pennsylvania are also going ahead with neural networks for signal processing—training networks to identify enemy vehicles by their radar or sonar patterns, for example.

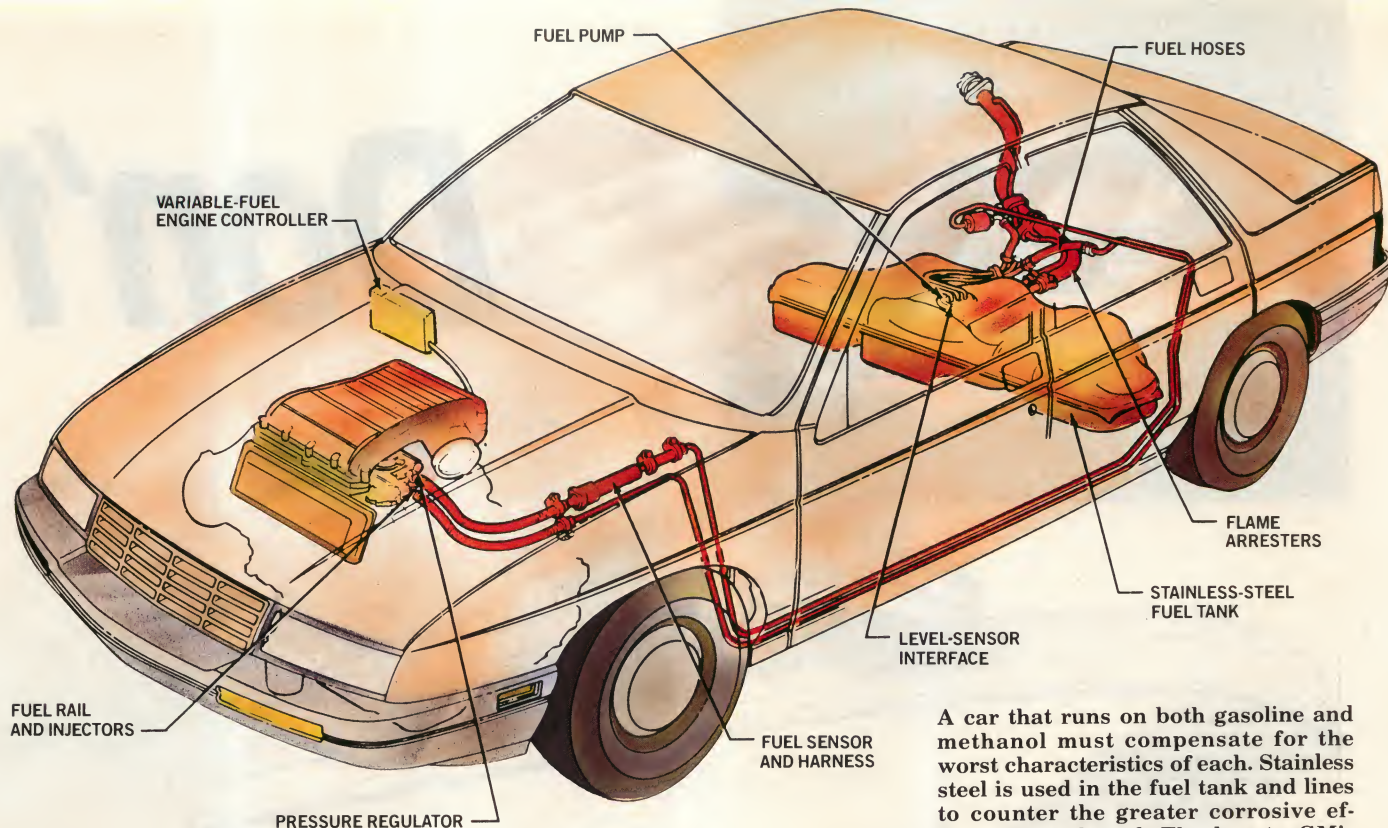
Still, there are some groups concentrating on neural-network chips. At Bell Laboratories a group headed by solid-state physicist Larry Jackel constructed an experimental neural-net chip that has 75,000 transistors and an array of 54 simple processors connected by a network of resistors. The chip is about the size of a dime. Also developed at Bell Labs is a chip containing 14,400 artificial neurons made of light-sensitive amorphous silicon and deposited as a thin film on glass. When a slide is projected on the film several times, the image gets stored in the network. If the network is then shown just a small part of the image, it will reconstruct the original picture.

Finally, at Synaptics, CalTech's Carver Mead is designing analog chips modeled after human retina and cochlea.

[Continued on page 110]

**“Hopfield should be known as the fellow who brought neural nets back from the dead”**





A car that runs on both gasoline and methanol must compensate for the worst characteristics of each. Stainless steel is used in the fuel tank and lines to counter the greater corrosive effects of methanol. The key to GM's system is a fuel sensor (under hood) that passes the fuel through electrically charged plates and measures the blend's capacitance. Changes in the dielectric constant are read by the engine controller, which adjusts the fuel injection pulses accordingly. Because methanol fumes can burn even inside an enclosed fuel tank, flame arresters are installed as a preventive measure.

# The any-fuel engine

Auto makers have developed engines that can burn a variety of fuels by sensing the composition of each blend and adjusting the fuel-injection system to use it efficiently. The new technology promises that methanol may be practical as a cleaner-burning alternative fuel.

By DAN McCOSH

**R**unning out of gasoline is a lot less annoying than running out of other, less conventional fuels. At least that's the conclusion I've come to after running out of diesel fuel in the middle of the night (not to imagine running out of powdered coal, ethanol, hydrogen, or any of the other alternative fuels I've tested over the years).

Recently I drove a Chevrolet Corsica that ran on a 75-percent mixture of methanol (an alcohol primarily derived from natural gas or coal) and gasoline. But this time I wasn't worried about an empty tank of hard-to-come-by methanol. A row of liquid-crystal lights on the Corsica's instrument panel indicated the percentage of methanol in the fuel line, which could be any combination with gasoline ranging from 0 to 100 percent. I could dump gasoline or methanol—or both—in the tank, and by the time it reached the modified 2.8-liter V6 engine under the hood, a computer would have quietly adjusted the fuel-injection system to account for the difference.

The multi-fuel project car is the latest effort by researchers at General Motors to produce a vehicle that can easily adapt to methanol fuel blends in the real world. GM's ex-

perts have concluded that methanol is the most practical alternative fuel likely to be in plentiful supply during the next century. Cleaner burning than gasoline, the alcohol can be refined from either coal or natural gas, both of which are available in quantities at least equal to the crude oil that is the basis of refined gasoline, according to David Dimick, executive engineer for GM's advanced product engineering staff.

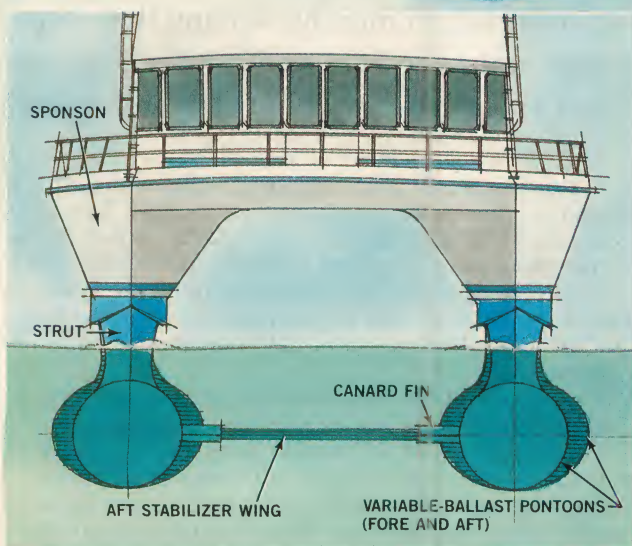
There's never been any problem getting an internal-combustion engine to run on pure methanol; the oxygen-rich high-octane fuel is popular with racers. But pure methanol is corrosive to many standard fuel-system components and has other problems, including a potential safety hazard: The fumes above the liquid in the tank can spontaneously ignite—unlike gasoline fumes, which are too rich to burn inside a gas tank.

Produced in volume, methanol is more expensive than gasoline, at least with gasoline prices in the United States now near a low point. But it is substantially less costly than ethanol alcohol derived from grain. Dimick told me that current estimates for methanol are about \$1.50 at the pump for the energy equivalent of a gallon of gasoline.

*(Continued on page 102)*



# Don't



*Chubasco*, the 72-foot Swath Ocean Systems yacht (pictured above and at the top) rides rough seas with the sea-keeping ability of a much larger single-hull boat design. Its high resistance to pitching, rolling, and heaving results from a special undersurface configuration called a small water-plane area twin hull (Swath). Most of the Swath yacht's flotation volume resides in the submerged pontoons that cruise the relatively calm water that lies below turbulent surface waves. In addition, horizontal fins and wings positioned between the struts counteract up-and-down motion.

Two novel boat hulls that reduce the rock and roll of rough seas are being fitted to luxury pleasure craft. The catamaranlike hulls gain stability differently: One has submerged pontoons that cruise smoothly below waves; the other has a cushion of pressurized air that rides above the turbulence.

By **BILL McKEOWN**  
Illustrations by *Barry Ross*

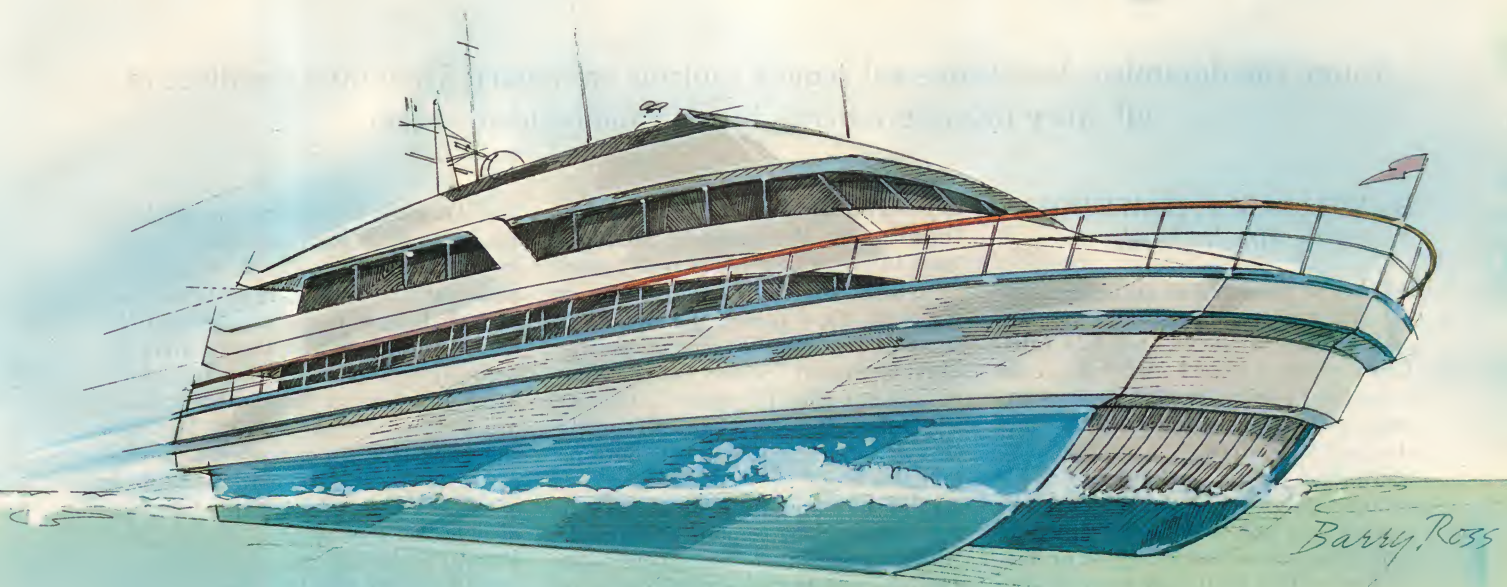
**A** pair of innovative marine hull designs is joining pills, medicated patches, and brewed potions to prevent that ancient curse of the unruly seas—motion sickness. Though these high-stability hull configurations have been used previously on large naval and commercial vessels, only recently have they been adapted to high-priced pleasure boats.

Key to both of these novel hull shapes is that they avoid riding the turbulent water surface where waves make conventional single-hulled vessels pitch, roll, and heave. Instead, they cruise where the going's much smoother: either above or below the ever-moving waterline.

During the 1986 America's Cup yacht race in Australia, the *Betsy*, a tender for the winning *Stars and Stripes* sailboat, cruised the ruffled waters off Perth along with many



# rock the boat!



other boats. Unlike the other boats, *Betsy* oscillated a lot less in the waves. Soon landlubber cameramen with queasy stomachs began to favor it as the preferred platform for filming the race. "It was like reporting from an aircraft carrier," one ESPN sportscaster remembers. *Betsy* was signed on once more for last year's A-Cup event.

*Betsy's* secret lies below the water surface. The boat has a special underwater shape called a small waterplane area twin hull, or Swath, to keep her on an even keel.

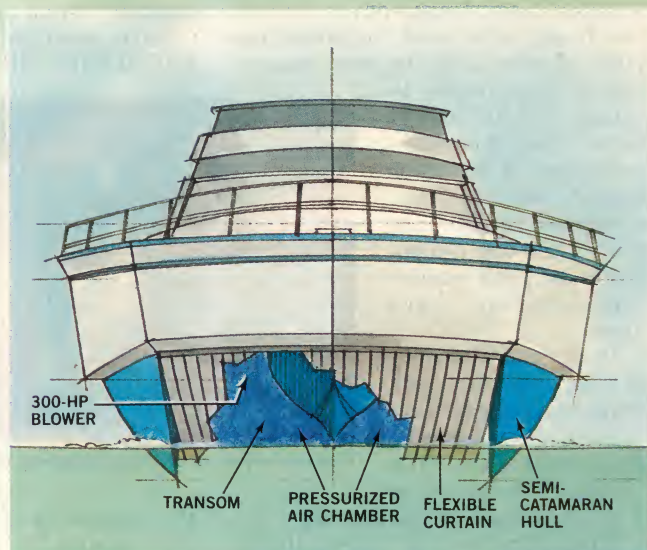
Now sharing this Swath shape is the latest development for smoother pleasure boating, a 72-foot aluminum luxury yacht called *Chubasco*. The multimillion-dollar concept craft, built in San Diego by Swath Ocean Systems, is on sea trials in the Pacific off California.

## Below the waves

Looking like a raised-deck catamaran mounted on struts, the *Chubasco* rides with the cabin 10 feet above the water. Unseen 10 feet below the surface waves are bulbous pods at the fore and aft ends of twin cigar-shaped pontoons. These pods act as stabilizers to keep the craft from rolling. They improve the Swath boat's stability because its flotation volume lies in the calmer waters below the surface turbulence.

Horizontal canard fins extending partway into the center tunnel from both forward bulges and a stabilizer wing connecting the aft pods help dampen pitching and rolling as well as allow *Chubasco* to bank into turns. The larger Coke-bottle-shaped bulges at the stern house twin 750-

[Continued on page 102]



A surface-effect ship (SES), such as the 87-foot Cheoy Lee/Air Ride pleasure craft (shown above), provides stability in rough seas by using an air cushion to raise most of the hull above the waves. Unlike a hovercraft, an SES encloses its blower-maintained air cushion within a blind tunnel formed by catamaranlike side hulls, a stern wall, and the water surface. At the bow a flexible curtain closes off the escape of air forward.



# Super remotes

Dump the dummies. New universal remote controls are smart: They take the place of all other infrared remotes in your audio-video system.

By WILLIAM J. HAWKINS

Photos by Jim Richards

**T**hey're scattered on my coffee table like a baseball-card collection: TV remotes, VCR remotes, CD, tape. Every piece of gear I own has a cute hand-held controller, and each is littered with dozens of tiny buttons—and they all look alike.

Groping in the dark to zap a TV commercial, I could zip the satellite dish across the heavens by mistake. And to do two simple things at once—like start the VCR and turn up the volume—I need the dexterity of a pianist and the confidence of an astronaut. But I've found a cure.

"They're called universal remotes," says Ed Juge, director of market planning for Tandy. Unlike other remotes, which are factory set to control one piece of gear only, the new versions can be programmed to mimic the actions of three other remotes—regardless of brand or model. Result: "One universal remote can control all the components in your audio-video system," says Juge.

Tandy and a variety of other manufacturers make these smart controllers. Prices vary—from about \$60 to \$130—but as I found out, so does their built-in intelligence.

When I first pointed Onkyo's Unifier remote at my hi-fi and pressed a button, nothing happened. Why? "Universal remotes must learn the codes used by your system," says Juge. Remote controls produce infrared light that's "seen" by all components. But the light is coded so only a specific component goes into action. To work, a smart remote must first be put in

a *learn* mode (you throw a switch), then taught the codes by letting it "see" the light your old remote makes.

To teach the Onkyo how to turn on my Sony TV, I placed the remote in front of its original remote control. Then I pressed "power" on the Sony remote and the "TV power" button on the Onkyo. In seconds an LED on the Onkyo told me to release the buttons: It had learned the code.

I did the same thing for all the buttons on the Sony remote—"channel," "tint," "color," and "sharpness"—assigning each to a separate button on the Onkyo. I then repeated the whole process for every remote in my system—from my Pioneer amplifier on the shelf to the NEC VCR in the rack. When I was through, I was in total control... well, almost.

Basic smart remotes like Drake's PRC/U, GE's RRC500, and Zenith's

and Onkyo's Unifier get up to three functions from each key. How? At the top of the remotes is a three-position slide switch. Slide it to one position, and each button does a certain job. Choose another, and the buttons do something entirely new. Yamaha's MRX-100 is a bit fancier. Its buttons are divided into two key pads; between the pads is a hinged plastic overlay card. As you flip the card over either of the key pads (like turning the page of a book), the buttons change jobs. Result: Each key can do two tasks.

Still others, like the Memorex CP8 and Tandy's URC, use a single "select" button and an LCD display. When you press "select," the LCD shows a new item—TV, VCR, SAT, CABLE, CD, RCVR, AUX1, or AUX2—and the keys change their job.

Slide switches? Plastic overlays? LCD displays? All to watch TV? Don't ruffle your popcorn. There are other ways to use some of these controllers.

For the video connoisseur there are three additional buttons on the Yamaha remote that can be programmed to perform multiple work. I set one for watching a videotape. I pressed one button, and the remote sent a sequence of codes to turn on the TV, VCR, and surround-

sound amplifier, then start a prerecorded tape and adjust the volume.

But for the true couch controller, Memorex and Tandy have added *five* built-in timers to their controllers' 24 programmable keys. Now the remote's back on my coffee table, but I no longer touch it. I sit, relax, and at a preset time, the movie begins automatically.

"Now that's remote control," says Juge.



Pioneer's remote learns infrared codes by "watching" another remote.

PCC operate up to three components—such as your TV, VCR, and cable box or satellite dish—and are the simplest to use. But many remotes, like Marantz's RC-20, can be used with more than three pieces of gear, and that creates a problem. How do you control lots of components without making the controller look like a NASA computer? The cures vary enormously.

For example, Pioneer's CU-AV100






Universal remotes, like GE's Control Central above, replace all the remotes in your system by mimicking their commands.



# Glue guns go cordless



That old glue gun gotcha roped and tied to an outlet? Now five heat-storing hot-melt slingers and one battery-toting rechargeable can glue where no gun has glued before. And riding the new wave: innovations in glues too.

By **PHIL McCAFFERTY**  
*Photos by John B. Carnett*



**W**hen I first reported on glue guns for the May 1984 issue of POPULAR SCIENCE, I had to snip off their power cords to arrange them attractively for photography. Such picture-taking peccadilloes aren't required with this latest batch: They're cordless. Hassle-free photography aside, you may find that many of the places you want to use a glue gun are more accessible when you're unhampered by a cord.

As I write, there are six cordless glue guns available, but the way they are proliferating there may be more by the time you read this. New hot-melt adhesives are also sprouting like mushrooms. Not long ago there was one all-purpose glue stick and one kind of caulk available to consumers. Now there are lots of different formulas for different functions. More on that later.

Five of the six cordless glue guns—from Black & Decker, Emhart, Loctite, Parker, and Stanley—have much in common:

- They are batteryless.
- They run cordless for 12 to 15 minutes.
- They heat up in 1½ to 5 minutes.

- They have a dual-connect feature allowing both corded or cordless use.
- They reheat in one to three minutes.
- They accept standard ½-inch glue sticks.
- They are trigger-fed.
- Prices range from \$15 to \$30.

But be forewarned: These five guns can't stray far from a power source for long. Without batteries, the guns rely instead on an insulated heating chamber to keep the glue at its optimum working temperature. While manufacturers are reluctant to discuss design details, Emhart says its Thermogrip gun's heating chamber is larger than in an AC-powered gun and made of materials that absorb and retain heat.


The batteryless glue guns won't emit a steady bead of hot-melt glue or caulk for their 12- to 15-minute cordless work time, but I found that they remain hot enough during that period to do average, intermittent jobs. You then have to plug them in for two to three minutes to get them back up to temperature. I found that the length of time they function also varies with the brand and type of glue stick or caulk used.

The guns are similar in style, but differ slightly when it comes to their charging stands. Parker's glue gun doesn't have a stand—only a retractable wire bail to keep the gun erect, nozzle pointing down. Thermogrip's and Loctite's both have basic charging stands. Stanley's bench-mountable work station provides a drip tray as well as storage for extra glue sticks and three additional nozzles. Black & Decker has the most elaborate setup. Its glue gun is sold with or without a Glue Gun Center, which includes storage space for glue sticks and a drip tray. In addition, this base has hot-melt application instructions printed on the side.

The maverick of the untethered breed is Ungar's rechargeable glue gun (\$40). It is much smaller than the other five. Nevertheless, it can deliver hot-melt adhesive for approximately 30 minutes—about twice as long as the others. The reason: It's powered by rechargeable nickel-cadmium batteries housed in the handgrip.

The batteries take 14 hours to recharge. After switching on, it takes about 90 seconds for the gun to heat up. The Ungar does have its draw-

*[Continued on page 104]*




Shown from the left (below) are Parker, Stanley, Loctite, Ungar, Black & Decker, and Thermogrip cordless glue guns.











Sure they cure in seconds, but for many people the so-called superglues too often have been blooper glues. If you've had problems, maybe you were using the wrong formula or using the right one incorrectly.

# Secrets of the superglues

By A. J. HAND

**H**ave you ever tried one of those super-fast cyanoacrylate glues only to be disappointed by a weak bond or even no bond at all? If so, you are not alone. When those tiny tubes of revolutionary adhesive came out several years back, I tried them dozens of times on all kinds of materials and finally gave up in disgust. Sometimes they worked perfectly, but more often they failed miserably. And everyone I've ever talked to has had the same experience.

It doesn't have to be that way. About two years ago I stumbled onto a brand of cyanoacrylate that really works. This stuff comes in three different viscosities, and the maker, Satellite City, Inc., also offers a spray-on catalyst, or cure accelerator. With this superglue I started getting consistently good results. I talked to experts, learned more about these glues, and began getting even better results. Recently I've found other brands of high-quality cyanoac-

rylates. I've also learned the reasons behind those early problems.

## Super discovery

Serendipity played a starring role in the discovery of superglue. During World War II, its inventor, Dr. Harry Coover (now president of Loctite Corp.'s new business development group), was a young chemist working at the Kodak Research Laboratories in Rochester, N.Y., looking for an optically clear plastic for gun sights. "I was working with some acrylate monomers that showed promise," he relates. "But everything they touched stuck to everything else. It was a severe pain."

1951 found Coover supervising a group of chemists at the research laboratories of Tennessee Eastman Co. Their mission: to find a tougher, more heat-resistant acrylate polymer for jet canopies. One of the group, Dr. Fred Joyner, spread a film of ethyl cyanoacrylate between a couple of prisms of a refractometer to check its refractive index. He made the measurement, but couldn't pry the prisms apart. "He came to me to report that he had ruined a seven hundred dollar instrument," Coover recalls. "It was then I suddenly realized that we had a unique adhesive." Years of work remained before cyanoacrylate became a viable product. Eastman 910, an industrial adhesive, was introduced in 1958.

Cyanoacrylates are reactive monomers that polymerize (chemically link)

*Continued*

Cyanoacrylates, in one- and two-ounce bottles, come in various viscosities. Shown (zigzag from upper left) is Sig Manufacturing's thin type; Pacer Technology & Resources's Zip Kicker (an accelerator that speeds the cure); Slow Jet, an extra-thick formula from Carl Goldberg Models; Pacer's Flex Zap, a thick formula that's more flexible than most when cured; PIC's Stic medium-viscosity formula; and Satellite City's thin formula, Hot Stuff. Set times range from two seconds to two minutes.

PHOTO BY JOHN B. CARNETT



when pressed into a thin film—and only then. Under normal conditions “all surfaces have at least a monomolecular layer of water on them,” Coover explains. “It’s actually the water, or any weak base, that is the catalyst causing the polymerization.”

The original cyanoacrylates were water-thin and good for gluing nonporous surfaces only: metal, glass, rubber, some plastics. Later, thickeners and other agents were added by some companies to adapt the adhesive for wood, leather, ceramics, and such.

All cyanoacrylates bond flesh well, as nearly every user knows. This generally causes no problem, for acetone (lacquer thinner or nail-polish remover) will dissolve the glue and free your flesh. But beware of tots bearing superglue. A medical journal recently described the case of a man who had to have a plug of cyanoacrylate surgically removed from his ear. It seems his three-year-old son squirted in a glob of glue while daddy slept.

### Trouble with superglue

The problems most people have with cyanoacrylates are tame by comparison: merely poor or failed bonds. Why does this happen?

There can be many reasons. Sometimes the trouble starts in the plant. Bob and Bill Hunter, a father and son who head Satellite City, Inc., voiced the same opinion: “Inferior drugstore cyanoacrylates often are of poor quality to begin with.”

“Most are imported from Japan or Taiwan, where some producers don’t spend enough time in refining,” Bob Hunter explains.

“If the cyanoacrylate isn’t properly prepared, it will have a short shelf life,” Coover elaborates. So the makers of the low-quality stuff add excessive stabilizers to keep it from curing in the tube. “The result is poor performance,” Coover goes on, and he explains why: “The stabilizers are acidic materials. If the concentration is too high, it will overcome the catalytic effect of the minute amount of moisture on the substrate and nothing will happen. A lot of the imported materials perform well,” he adds, “but those sold at the low end of the market have given cyanoacrylates a bad name.”

“Somebody buys the inferior stuff to do a specific job, bonding things that are important,” Bill Hunter laments. “The glue fails, and he gets the im-



PHOTOS BY A. J. HAND

pression that CA [cyanoacrylate adhesive] is just for fun.”

But good CAs—used properly—are not just for fun. They are used every day by hundreds of different industries. Museums soak brittle bones and fossils with the glue; it helps bind them together and give them strength. Burt Rutan used Satellite City adhesives extensively in the construction of his *Voyager*, the lightweight airplane that flew around the world [Sept. '84].

CAs can have a tensile strength of 4,000 to 5,000 psi, or roughly four times that of white oak. Says Bill Hunter: “For all practical purposes it’s overkill.”

### Glues to choose

Some of the products you buy in the tiny tubes at the hardware or drugstore are fine for the quick repair jobs they’re made to do. (Coover claims that his company’s Duro Quick Gel is “technically the best one out there. It has



Color-matched wood filler is easy to make right on your work (above left). Just dribble one of the thicker cyanoacrylates into a crack, hole, or gouge, then sand to pack a slurry of glue and wood dust into the blemish. Mist with kicker, and the repair is cured and ready to finish.

Superglues are super handy for lathe work (above). You can glue small workpieces to a faceplate or, as shown, tack the plate in position on large work to keep it from shifting while you screw it down. The author also used cyanoacrylate to laminate the turning blank that became this Egyptian-style vase—a five-minute job.

Cyanoacrylate plus fiberglass cloth becomes fiberglass-reinforced plastic in less than a minute (left). Here a wood-aluminum joint is being reinforced. The glass was tacked down with a mist coat of 3M 77 rubber-base spray adhesive. A thin cyanoacrylate was then soaked into the cloth and misted lightly with kicker. Strength is exceptional.

an additive that makes it, in my judgment, foolproof.”)

But the tiny tubes are not convenient for me: I use CAs too profligately. And they are not economical: I buy cyanoacrylate in one-ounce bottles for around \$10. At my local drugstore, a tube containing 0.07 ounce costs \$2.50. That works out to nearly \$36 per ounce!

After working with Satellite City glues for over a year, I started running into other makers, all marketing CAs for the hobby trade, and like Satellite City, all offering various viscosities—in one- and two-ounce bottles—plus spray-on cure accelerators. Among these makers are Pacer Technology & Resources, Sig Manufacturing Co., PIC, and Carl Goldberg Models. Now (too late to be included in our photos) I’ve learned that 3M has joined the ranks. There may be others.

I tried some of these products around the shop, and for my purposes, they



seemed to work as well as Satellite City products. Others have found significant differences though. When *Scale Radio-Control Modeler Magazine* tested the tensile strength of two cyanoacrylates for a piece it ran in its January-February 1987 issue, Satellite City's Hot Stuff came out on top, "... almost two times stronger on average than the brand with which it was compared," according to the article. In that test fiberglass circuit board was glued to itself. Fiberglass was chosen because it's a difficult test material: smooth, nonporous, and strong enough not to fail before the glue itself.

Nevertheless, when I spoke with the magazine's publisher, Norm Goyer, he pointed out that for most jobs around the home all the products named above serve him well too. Generally, the material being glued will fail before the bond does.

The moral of all this? For simple gluing jobs—involving wood, most plastics, rubber, etc.—any good CA should work. If you have a particularly difficult job—gluing metals or composite materials, for example—it may pay to choose your glue more carefully. Check to see if it conforms to Military Spec MIL-A-46050-C, or ask the maker for test data on the actual materials you plan to glue.

### Use it right, too

Getting good results is more than a matter of buying a quality glue, however. You also need the right formula for the job you're doing, and you have to use it correctly. Rule one is this: Don't expect the water-thin cyanoacrylates to do every job. (Most drugstore brands, unless the tube says otherwise, will be this type.)

"With CAs," notes Tom Nightingale of Pacer Technology & Resources, "the gap-filling capacity is directly related to viscosity." You use the watery versions on parts that are smooth, tight-fitting, and relatively nonporous. These glues set fast; so when gluing a joint you must assemble the parts dry, then apply the adhesive around the edges of the seam. It wicks deep into the joint by capillary action and cures in seconds.

Because these CAs are so thin, they will not wick into loose joints, and they won't bridge gaps. They're not much good on porous materials either. They get soaked up before they can wick throughout the bond area.

That's where the higher-viscosity formulas come in. Makers offer medium viscosities (like syrup) and thick glues (like a mixed epoxy). These are thick enough to bridge small gaps and to resist being sucked out of the joint. You apply them to the surfaces first, then

assemble the joint. Consequently they have slower cure rates. The thickest usually take about a minute to cure.

But if you are using them on sloppy joints with wide gaps to fill, cure time may extend to minutes or even hours. This is one case where the spray-on cure accelerators are indispensable. Just mist a light coat on one of the mating surfaces. It will dry almost instantly, but remain active for several minutes. Apply your glue to the other part, then assemble the joint. The accelerator will normally kick the glue over in seconds.

**"C**yanoacrylates are odd beasts. Sometimes, despite your best efforts, you may still have problems **"**

In addition to different viscosities, Pacer makes special formulas such as Poly-Zap for bonding difficult plastics like polycarbonate and polyamide nylon, and Plasti-Zap which contains ingredients to overcome the mold-release agents often found on the surfaces of plastic model parts.

If you have specialized needs—and need large quantities—you might want to investigate the industrial lines of cyanoacrylates. Says Nightingale: "We have over one hundred different formulations and materials in the CA family."

For use around the shop and home, however, the three basic viscosities I've mentioned should be adequate. In fact, I find I don't have much use for the medium-viscosity materials. I either want the fast set and excellent wicking of the thin formulas, or I want the gap-filling ability and the longer assembly times of the thick formulas.

### Sticky but tricky

Cyanoacrylates are odd beasts. So sometimes, despite your best efforts, you may still have problems with them. Common causes are:

- **Poor fit.** Even though thick formulas can fill small gaps, the better the fit, the better the bond. Always check mating surfaces before bonding. Smooth them up and remove any burrs or rough spots. Kickers help, but it's best to aim for a good fit in the first place.

- **Too much glue.** Never use more than necessary. According to Bill Hunter, "Optimum results are obtained with the minimum quantity of adhesive required to fill the joint. In general, one free-falling drop spreads over one square inch." It takes some experience to know how much glue is enough, so it's a good idea to experiment on scraps of your material—making joints, then tearing them apart to check coverage.

- **Premature curing.** Do not spread your glue before you assemble the parts. This encourages it to start curing. Instead, lay down a serpentine bead, then assemble the parts, letting pressure squeeze the bead out into a thin film.

- **Premature stressing.** Although CAs cure in a matter of seconds, this initial cure is only about 20 percent of full strength, which is only reached after 8 to 24 hours. Give the bond ample time to cure before subjecting it to much stress.

- **Surface contamination.** CAs are more tolerant of this than most glues, but they still work best on clean surfaces. Waxes, oils, and excess moisture can act as barriers between glue and substrate, and this can lower bond strength.

- **Acidic surfaces.** Since alkalinity triggers the cure, it's not surprising that acidity inhibits it. To solve this problem, you can use a kicker on one of the mating surfaces. These are essentially organic amines that "supply a heavy dose of alkalinity," as Bill Hunter puts it.

- **Low shelf life.** The Hunters recommend storing unopened bottles of CA in a freezer. Frozen, the adhesive should last at least two years. Once the bottle is opened, however, shelf life drops to about six months. Moisture in the air gets in, starts the curing process, and the glue gets progressively thicker until it is too gummy to use. They do not recommend refrigerating or freezing bottles that have been opened.

- **Cold.** Users who store CA in the fridge or freezer may take it out and use it cold. They apply it as usual, and the joint simply falls apart. What happened? "The polymerization is not terribly sensitive to temperature," explains Coover, "but when the glue is cold it gets thicker, and it may not get

[Continued on page 104]



# Gel stains

Staining used to mean working with hard-to-control watery solutions and dealing with lap marks, streaks, and inevitable runs and drips. Thickened creamy wipe-on stains from companies such as Behlen & Brothers, Fabulon, Flecto, Formby, Minwax, and Wood-Kote are easier to control and easier to work with, and they all but eliminate application errors. What are their secrets?

By **TIMOTHY O. BAKKE**  
*Photo by John B. Carnett*

Unlike watery conventional stains, thickened gel stains like this one from Minwax don't run uncontrollably.

**Y**ou've just finished stripping and lovingly restoring your grandfather's favorite side table, with its intricate carvings and turned legs. Now you're ready to stain it. But you remember that the watery stain splashes when you stir it and can spray off the end of your brush, puddle in the carvings, drip and run on the turned legs, and, even if you're extra careful, form lap marks between adjacent areas finished at slightly different times. You dread having to face the mess.

You don't have to.

With modern stains called gel or wiping stains, you wipe the color onto the wood with a cloth and avoid all the problems listed above and more. The stains—Behlen's Master Gel, Fabulon's Gel-Eze, Flecto's Varathane X-3D, Formby's Wiping Stain, Minwax's WoodSheen, and Wood-Kote's Gelled Wood Stain—are oil-based formulations that are easier to work with and more forgiving than conventional stains. They also allow you to do things that are difficult if not impossible to do with conventional stains, such as lightening the color or color-matching existing stains as you apply the gel stain.

What exactly are these stains? How did they originate? How do they differ from conventional stains? How do they perform and what can you expect of them? I visited a leading wood-finish manufacturer's labs and spoke with other experts in the field to find the answers to these questions and more.

Thickened wood-finishing stains are not new. There have been other such products over the years, but according to a spokesman from Thompson & Formby, with the exception of Wiping Stain and Wood-Kote's stain, which were introduced in the late 1960s and have since been reformulated, those products did not perform well and have gone the way of the dodo. This past year, however, seems to have been the

[Continued on page 105]









# Mobile miter box



Mount it on a sturdy stand with wheels, and a power miter box becomes a tool that goes where the job is. Fold-up table extensions let the saw handle extra-long work pieces.

By R. J. De CRISTOFORO

I've always enjoyed working with a power miter box, and I got to like mine even better after using it to size, miter, and notch rafters for a backyard storage building. It was just the tool for the job. But I realized that the machine would be more practical, easier to use, and safer if I equipped it to provide considerably more support than the typical 18-inch-long tool table offers. Customizing the miter box soon became a project in its own right.

Because a miter box is a machine that should be bolted down wherever it is used, it was natural to think of mounting it permanently on its own mobile cabinet. That way it could readily be wheeled around to the next work location. With fold-down table extensions on either side, the unit could accommodate both small and larger pieces of work while occupying a minimum of floor space.

The cabinet I built offers much more than extra work support. Storage space for blades and accessories, removable clamps for work security, stop blocks for sawing similar pieces, and a guide for compound-angle cuts are all part of the design.

The cabinet's legs are notched to accept the front and back rails and

are grooved on their inside edges to secure the panels and side rails. The side rails have tenoned ends and are grooved, like the legs, on their inside edges for the panels. Put the legs and front and back rails together as sub-assemblies and then connect them with the top side rails using glue and clamps. Slip in the panels, then add the bottom side rails, again using glue and clamps. It isn't necessary to glue the panels in place; they'll stay put without any help.

## Have wheels, will travel

The legs have casters for mobility, with a locking feature that's important for safety while sawing. One way to arrange the casters for maximum stability is to use fixed casters on the back legs and swiveling casters on the front legs. That way the machine won't have too much of a mind of its own when it's being wheeled to a new location.

Install the shelf cleats and the shelves before adding the back, which is simply surface mounted and secured with three-penny nails. The position of the top shelf is arbitrary and can be chosen to suit the items you wish to store. Be sure to recess the front edge of the shelf so there will be room for the perforated hardboard and tools stored on it when the door is closed.



For long work, the mobile miter box's wings lift (sketch above left) to provide nearly 8 ft. of work-support surface. Lower ends of adjustable braces bear against cabinet's bottom side rails. Work can be performed with one or both wings up, from either side of the table. When not in use (top photo), drop leaves fold for compact storage in workshop. Wood-bar-clamp fixtures (middle photo) are mounted for easy removal; their studs slip into sockets drilled in the clamp blocks. Stop blocks (above) are used to gauge length of duplicate miter-cut lengths. After first miter is cut at one end, stock is flipped end for end to butt against the block.



It's best to install the door at the end of construction so it won't interfere with any work you'll have to do inside the cabinet. A sheet of perforated hardboard attached to the back of the door provides storage space for blades and other accessories that can be hung from hooks.

Cut the top to size, attach the trim pieces with glue and three-penny nails, and secure it to the rails with No. 10-by-1½-inch flathead screws. Assuming all the parts have been sanded, it's a good idea at this point to apply a couple of coats of sanding sealer, sanding lightly between coats and once more after the final one.

Bolt the saw in place so it is centered on the cabinet with the front edge of its base parallel to and 5¾ inches from the front edge of the cabinet's top. Before continuing, check to be sure the saw's components are in correct alignment. The table must be level. The angle between the surface of the table and the side of the blade must be 90 degrees. The angle between the fence and the blade at zero setting also must be 90 degrees. Any adjustment of miter settings can be attended to later.

Before cutting parts for the fixed table extensions, check the height of the saw's table against the dimensions

that are supplied in the drawing and make any necessary changes to fit your saw. The extensions are assembled as units and then attached to the cabinet with No. 10-by-1½-inch flathead screws. The clamp blocks are notched to fit the base of the extension and are drilled to accommodate the studs on a pair of wood bar clamp fixtures. Hold the blocks in place with clamps after coating mating edges with glue.

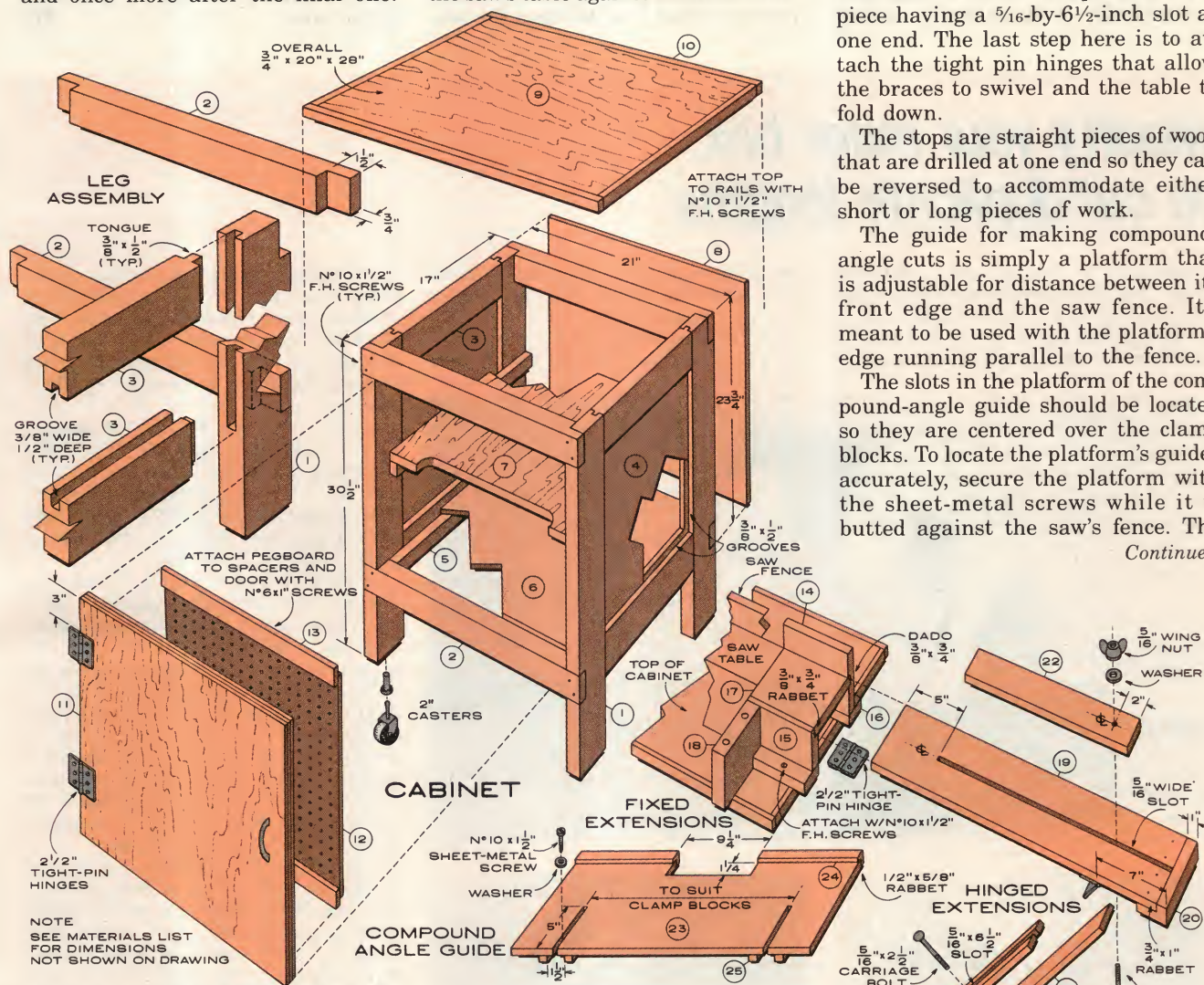
Cut the tables to length and then form the 5/16-inch-wide slot. Close the open ends with the ties, using glue and three-penny nails for the attachment. The braces are duplicates, each piece having a 5/16-by-6½-inch slot at one end. The last step here is to attach the tight pin hinges that allow the braces to swivel and the table to fold down.

The stops are straight pieces of wood that are drilled at one end so they can be reversed to accommodate either short or long pieces of work.

The guide for making compound-angle cuts is simply a platform that is adjustable for distance between its front edge and the saw fence. It's meant to be used with the platform's edge running parallel to the fence.

The slots in the platform of the compound-angle guide should be located so they are centered over the clamp blocks. To locate the platform's guides accurately, secure the platform with the sheet-metal screws while it is butted against the saw's fence. The

*Continued*



# MATERIALS LIST—BUILT-IN POWERED MITER BOX

KEY PART	NO. PCS.	SIZE	MATERIAL
Cabinet			
1 leg	4	1½" x 3½" x 30½"	lumber
2 front and back rails	4	1½" x 2½" x 21"	lumber
3 side rails	4	1½" x 3½" x 11"	lumber
4 panels	2	¾" x 11" x 17¾"	particleboard
5 cleats	4	¾" x 1" x 15"	lumber
6 shelf	1	¾" x 15½" x 18"	particleboard
7 shelf	1	¾" x 15½" x 18"	plywood
8 back	1	¾" x 21" x 23¾"	particleboard
9 top	1	¾" x 19" x 27"	plywood
10 trim	2	1½" x ¾" x 28"	lumber
	2	1½" x ¾" x 19"	lumber
11 door	1	¾" x 18" x 18¾"	plywood
12 tool hanger	1	¼" x 13¾" x 15"	perforated hardboard

13 spacer	2	¾" x 1½" x 13¾"	lumber
Fixed extension (assumes saw table is 3¼" high)			
14 fence	2	¾" x 5¾" x 6½"	lumber
15 leg	2	¾" x 2½" x 6½"	lumber
16 base	2	¾" x 2" x 6½"	lumber
17 table	2	¾" x 6" x 6½"	lumber
18 clamp block	2	1½" x 3¼" x 5½"	lumber
Hinged extensions			
19 table	2	¾" x 6" x 30"	lumber
20 tie	2	1½" x 2½" x 6"	lumber
21 braces	4	¾" x 2½" x 22"	lumber
22 stop	2	¾" x 2¾" x 16"	lumber
Compound angle guide			
23 platform	1	5/8" x 9¾" x 27¼"	particleboard
24 ledges	2	¾" x 1" x 9"	lumber
25 guides	4	½" x ¾" x 5½"	lumber

**Hardware**  
Three pairs 2½" tight pin hinges with ¾" screws  
Four 5/16" x 2½" carriage bolts with washers and wing nuts  
Pull and magnetic catch for door  
No. 10 x 1½" FH screws  
No. 10 x 1½" sheet-metal screws with washers  
3d and 2d box nails  
No. 6 x 1" RH screws  
Four casters (fixed type for rear legs, lockable swivels are best for front)



guides should allow the platform to move easily but without wobble.

The purpose of the platform is to allow a workpiece to be leaned against the fence at a repeatable angle. Making a routine 45-degree miter cut results in a compound angle with the slope determined by the angle between the work and the fence. If the slope angle is critical, you can determine the angle between the work and the fence with a T-bevel. Often, however, the slope angle doesn't have to be precise and actually can be judged visually. A picture frame would be a case in point: A few degrees one way or the other would not affect the project aesthetically or structurally, as long

as all pieces are cut to the same angle.

Having a special setup for the power miter box doesn't relieve you of the responsibility of working safely. Always keep the guard in place and keep your free hand well away from the danger zone. Using one or both of the clamps helps you work more safely and accurately.

When cutting, allow the blade to fully stop before removing workpieces—no time is lost here if your machine has an electric brake. Wear safety goggles; and it doesn't hurt, especially during long use, to wear headphone-type hearing protectors.

Occasionally you may need to make a crosscut that is wider than the saw

could ordinarily handle. This type of cut can be made by first taking a maximum-width cut, then turning the stock over and making a second pass to complete the cut.

A final pointer: Work with sharp blades. An all-steel combination blade that is efficient for general sawing is the original equipment on many saws. But if you want ready-to-assemble results, consider a blade like the Teflon fluorocarbon-resins-coated model Freud, Inc., offers. With its unique tooth configuration, this blade delivers such burnished-looking cross and miter cuts that it has become a favorite choice for use with miter saws. **P S**

## Modify your miter box to cut duplicate lengths

I frame pictures—a lot of pictures. But when I finally treated myself to a power miter box I found I couldn't easily cut the identical pieces of molding that frames are made from; the lengths rarely come out the same. I needed a

device that would mount on the saw and allow me to set a measurement to cut any number of pieces of equal length.

After thinking about what the ideal accessory would look like, I realized that a simple

solution already existed: A three-foot combination square was just what I wanted. Then I checked the price for one at several tool suppliers and recoiled in horror. There had to be a cheaper solution. So I set about designing a square that would do the job at an affordable cost.

I already had one key item: A standard 12-inch combination square that I had bought at a garage sale for \$2. I knew that if I could mate the head of the combination square with a three-foot metal ruler (\$12), I would have my problem solved. Fitting the two parts together turned out to be easy.

To attach the head of the square to the ruler, I modified a 1/4-inch bolt by grinding a notch into it with a length equal to the width of the ruler (see photo). Before I attached the ruler to the miter box, I cut off the first two inches of the ruler so the saw blade would clear it. Then I drilled two 1/4-inch holes about four inches apart in the ruler. With the head of the square on the 15-inch line of the ruler, I loosely clamped the ruler onto the miter box. I adjusted the ruler so it was parallel to the bed of the box, with the head of the square exactly 15 inches from the blade.

I had to decide if I wanted to zero the ruler with the blade set at 90 or 45 degrees. I chose 45 degrees because that's the cut I most often make. (I have to add 1/2 inch to each measurement when I need to cut with the blade at 90 degrees. Similar additions are made when cutting at other angles).

After I had marked the locations of the holes on the box, I center-punched and then drilled two 1/4-inch holes in the fence of the miter box. Then I attached the ruler to the fence with two 1/4-inch bolts and wing nuts. The wing nuts allow me to remove the attachment quickly when I want to operate the saw without it.

My miter box modification is a success and a bargain. If you have a power miter box you might find this a handy attachment to make for yours.—Steve Bryan



Bolt a combination square onto a power miter box and you've got a length gauge for making repetitive cuts (top). To handle longer lengths, replace the original 12-in. ruler with a three-footer. The close-up (above right) shows how



the longer ruler mounts through two holes drilled in the back of the saw fence. The original attachment bolt is replaced with a 1/4-in. bolt (above left) notched to allow the new ruler to slide through the head of the square.



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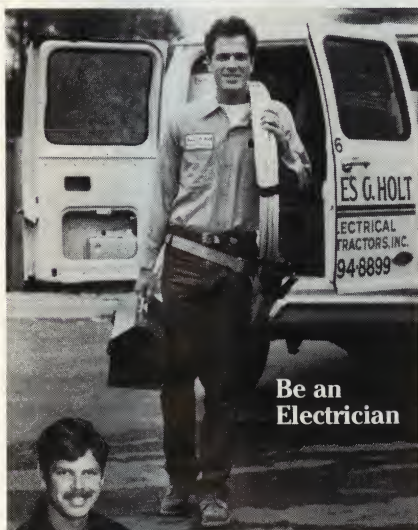
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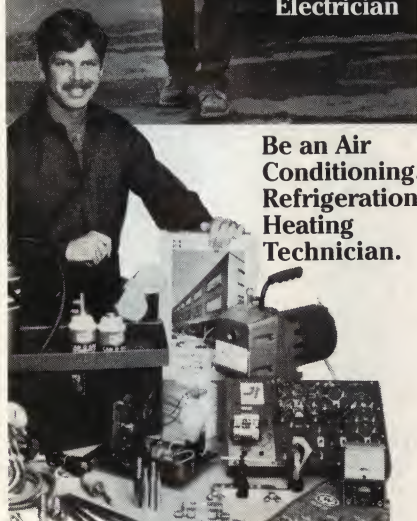
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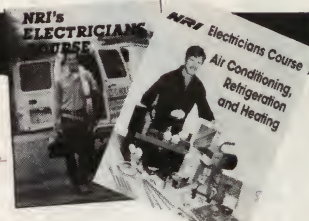
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# What's New

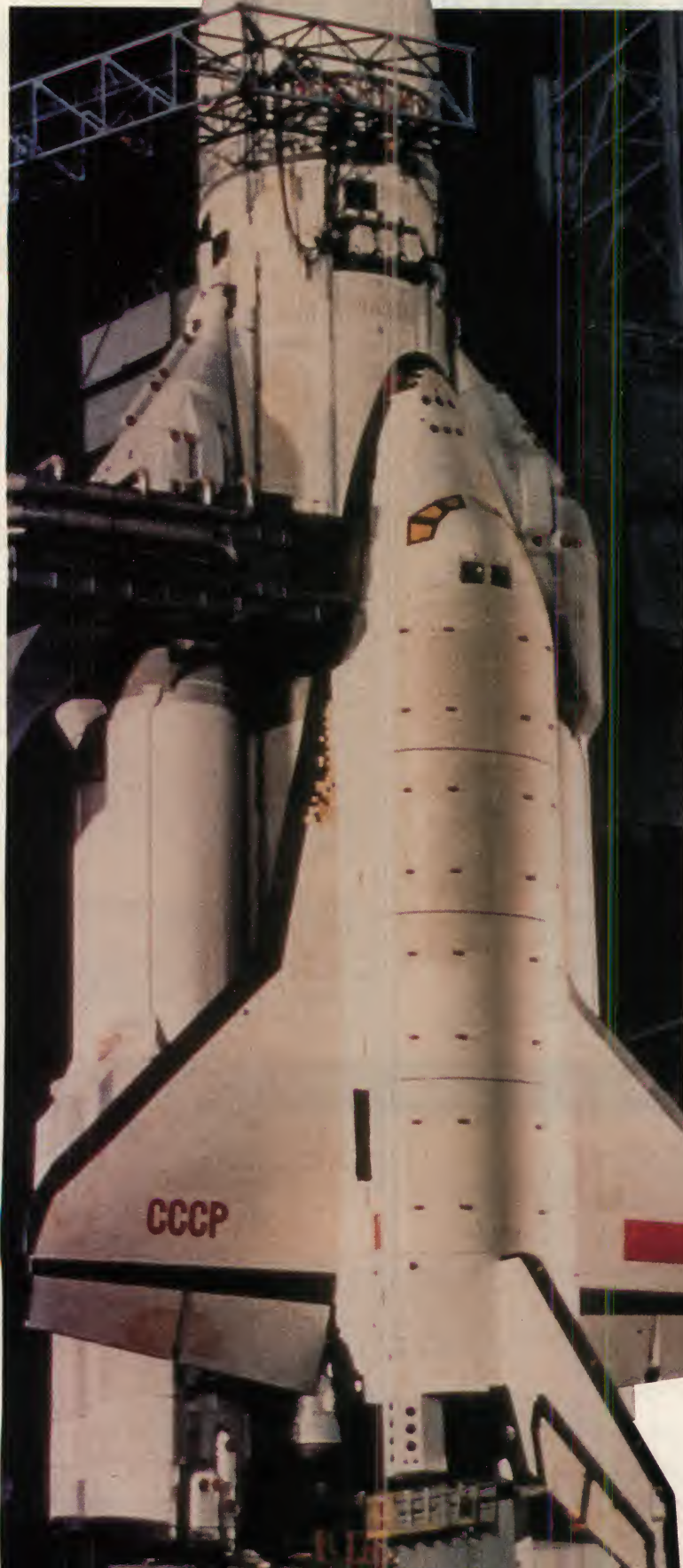


PHOTO BY SOVPHOTO



## Snow rake ▲

Shoveling snow can be a dangerous strain. The \$10 Sno-Ho pushes snow aside, so there's no bending and lifting. R. J. Engineering Co., 6515 Haggerty Rd., Belleville, Mich. 48111.



## Roomy hatchback ▲

Sold in Europe, the Volvo 440 resembles the 480 ES coupe—with the same chassis layout and Renault 1.7-liter engine. But the 440's engine was turned to provide extra interior space.

## ◀ Soviet shuttle debut

This is the first official photograph of the Soviet space shuttle Buran (meaning blizzard). Like the American spacecraft, it has delta-shaped wings and is attached to a booster rocket. Its unmanned first flight was in November 1988.



## Wall saver ▲

Post notes without tape or tacks. Apply Liquid Magnet, let it dry, then hang and rehang paper and other materials. PDI, Box 130, Circle Pines, Minn. 55014.





### Drip-dry and fly ▲

Using hoses and mops, it takes a crew of 20 more than four hours to wash an airliner. But with this \$8-million automatic rig, two workers can wash a 747 in only 45 minutes. Japan Air Lines engineers expect frequent cleanings to improve air-flow and save fuel.



### Backup batteries ▲

Bridgestone Corp. and Seiko Electronic Components developed these polymer lithium batteries to supply backup power to computers. The coin-type batteries, which use a conductive polymer as the cathode, last longer and provide higher voltage than existing lithium rechargeables.



### ◀ Spare wheels

Don't have time for a roadside tire repair? Unfold Quickwheel and drive up the ramp. You can load 1,320 pounds onto the fiberglass-filled polyamide wheels and drive at speeds up to 45 mph without any noticeable change in braking or steering, says Quickwheel, 52 Mason St., Greenwich, Conn. 06830. Price: under \$200.



### Steer-crazy car ▲

In Britain instructors use a fleet of Ford Fiestas equipped with electric power steering on both axles to teach skid control safely on a dry track. Wheel angle combinations can be programmed into the system, allowing students to repeat *tricky* maneuvers.





# What's New TOOLS



## Hammerless nails ▲

Quick-Nails have threaded shanks, three-pronged heads, and a grip up to five times that of regular nails, claims the maker. Drivers for (from left on wood) toenailing, flush nailing, and countersinking chuck into your drill. Remover (right) backs out seated nails. Drivers cost \$3 to \$4; nails, a few cents each. Sheet-metal screws (foreground) are also available. Ever-Tite Co., 20133 Delta Dr., Woodland Hills, Calif. 91364.



## New Twist on photovoltaics ▲

Sure, cordless tools free you from the electric outlet—for a while. When the battery needs a charge, though, it's back to the old AC. Now Skil Corp. introduces solar chargers for the Twist and Super Twist cordless screwdrivers. They'll keep the tools charged on boats, RVs, or anywhere electricity isn't. Price: around \$17.

## ▼ Recip to go

This reciprocating saw from Makita can go to the job site without trailing a cord. It will cut



nearly 40 feet of 1/2-inch softwood on a single charge of its 9.6-volt nickel-cadmium battery, it's claimed. Recharging takes an hour. Price: \$218 with battery and charger, \$110 without. Makita U.S.A., 14930-C Northam St., La Mirada, Calif. 90638.

## ▼ Three-legged horse

Cast-polycarbonate sawhorse brackets take three legs (cut of 2×4s) instead of two. The advantage? Improved stability, it's claimed. To store flat, you loosen four screws in each bracket. Price: \$11 a set at stores. Le Con Tool Co., 3715 State St., Bettendorf, Iowa 52722.

## Biscuit recipe ►

You can make biscuit joints with your Shopsmith Mark V and the company's new accessory. The \$99 biscuit joiner's horizontal saw blade, behind a spring-loaded fence, cuts arc-shaped slots in mating surfaces perfectly sized for premade compressed-wood biscuits. Glue swells the biscuits, forming strong joints. Shopsmith, 3931 Image Dr., Dayton, Ohio 45414.





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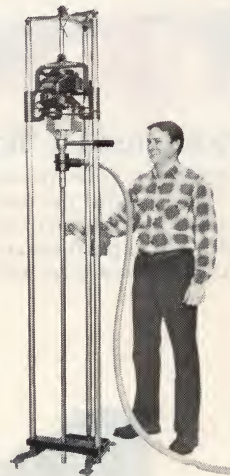
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# What's New PHOTOGRAPHY



## Two for instant-film fans ▲

Polaroid has introduced two new instant camera models, the Impulse and the Impulse AF. Both use Polaroid's 600 Plus film and have a pop-up flash. The Impulse, with a price of \$69, has a prefocused lens. The \$89 Impulse AF's auto-focusing system uses infrared and ultrasound.



## Flash meter

The Strobeframe/Shepherd FM-1000 digital meter works both to monitor incident or reflected flash and as a conventional ambient light meter. It has a two-digit light-emitting-diode display that reads out in one-third-stop increments, and a shutter-speed control for correct flash sync speed. Saunders, 21 Jet View Dr., Rochester, N.Y. 14624. The price: \$180.



## Dual-focus point-and-shoot ▲

The Kodak S900 Tele operates at two focal lengths, 32mm and 64mm, selected by a switch. Focusing is automatic in the tele mode, fixed in the wide mode. It's not yet available in the United States.



## Collapsing hood

The Hama Telematic lens hood is designed to collapse in clearly marked stages so that it matches the viewing angles of zoom lenses from 24mm to 210mm. It costs \$15 to \$17.



## A tough case ▲

Watertight, airtight, and rugged, the Andiamo Aerospace II carrying case has a one-piece shell and stainless-steel fittings to protect against salt water. It's \$200 from GMI (1776 New Hwy., Farmingdale, N.Y. 11735).



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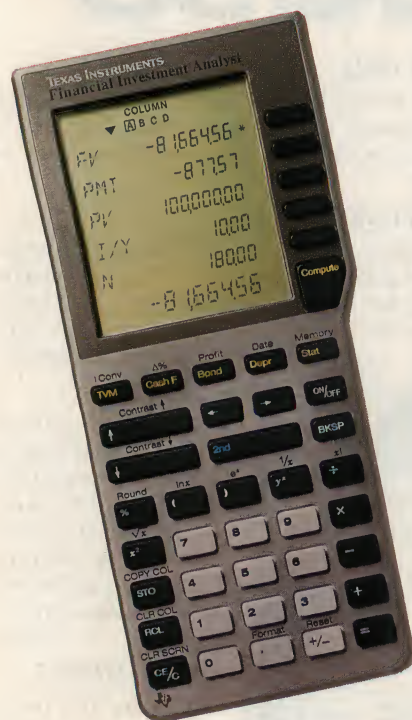
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# What's New ELECTRONICS



## Memo maker ▶

Got a great idea? Don't say it—display it. Sony's Video Memo Writer lets you create video reports, promotions, or electronic tutorials—with nearly professional-looking results—by editing 8mm video cassettes. Price: \$4,950.



## ◀ Multi-line problem solver

Texas Instruments' Financial Investment Analyst calculator quickly shows the answer, but the six-line display lets you see the problem as well. The \$175 calculator has 10 built-in worksheet models for financial applications, such as cash flow, depreciation, and amortization.

## Half-page scanner ▶

Stroke the Half-Page Scanner over text or graphics, and half the sheet of paper is "read" into your personal computer. Another stroke enters the second half. Software lets you put them together. It's \$299 from The Complete PC, 521 Cottonwood Dr., Milpitas, Calif. 95035.



## Remote lamp dimmer ▲

Plug a lamp into Honeywell's Tabletop Dimmer box, then plug the dimmer into a wall outlet. Aim your TV's infrared remote control at the box and press any button to dim or brighten the room light. Now you never have to leave your easy chair. It's \$40.

## ◀ Have-it-your-way computer

Tell the Headstart III computer if you're a beginner or advanced user—the menus on the AT- and PS/2-compatible systems change to keep up with you. With one megabyte of memory, three built-in drives, VGA graphics, and a variety of software, it's \$2,595 from Vendex Technologies, 40 Cutter Mill Rd., Great Neck, N.Y. 11021.





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APS-39



## The any-fuel engine

[Continued from page 73]

"But there's no mass-scale infrastructure in place to supply pure methanol, and we don't think there ever will be," Dimick added. This observation led to the development of the any-fuel Corsica I was driving.

The car modifications were surprisingly simple. Because methanol tends to attack conventional plated steel, the fuel tank and lines are made of stainless steel. Special plastics replace a handful of components that could be damaged by alcohol. Also, flame arresters are installed in the fuel tank to prevent spontaneous combustion of the oxygen-rich methanol vapor.

### Sensing the blend

The key to keeping the engine operating properly is a sensor in the fuel line that passes the fuel between electrically charged plates. Because gasoline and methanol have different dielectric constants (insulating properties), Dimick says, the fuel mixture can be read as differences in the capacitance between the plates.

The sensor readings allow the fuel-injection computer to adjust the mixture. Methanol has about half the energy content of gasoline by volume, so twice as much is needed to give equivalent performance, and injector pulses are lengthened accordingly. One side effect is that fuel consumption goes up dramatically as the mixture leans toward the methanol side.

The any-fuel car caps a series of methanol experiments conducted by GM. The company has equipped a test fleet of Pontiacs to use the alcohol. And in 1982 GM began supplying methanol-fueled test buses to a number of cities, most recently New York. These buses boast significantly improved exhaust emissions—particularly important in crowded cities where sooty diesel smoke is a visible despoiler of the air.

Ford developed its own multi-fuel system three years ago that was installed in a fleet of 30 LTDs. The key difference between the Ford and GM approaches is the method of sensing methanol mix. Ford's uses an optical sensor that relies on changes in the refractive index of the fuel, rather than its capacitance. Chrysler has developed a similar system too. Ford has supplied fleets of pure-methanol-burning cars to test the practicality of the fuel, mainly in California, where a limited number of methanol pumps are being installed in the Los Angeles area.

The experience gained in these test programs will be immediately useful to areas with severe local air-pollution problems, and valuable to the nation as a whole in the event a gasoline shortage develops in the future. **P 3**

## Don't rock the boat

[Continued from page 75]

horsepower General Motors turbodiesels, which push the *Chubasco* to a top speed of over 20 knots. The craft also maneuvers on a single engine.

*Chubasco's* skipper can flood these four submarine pods to add ballasting or flotation to compensate for the changing weight of the fuel load. The gyro-activated trim fins and stabilizer tailor hull position to the sea conditions for the smoothest ride.

The Swath yacht's controls include an autopilot, a video engine-room monitor, backup computers and manual override controls, and an auxiliary steering station as well as advanced navigational and communications systems.

### Smooth sailing

During recent runs through steep 10-foot seas in a roiled area of water called Potato Patch near San Francisco's Golden Gate Bridge, *Chubasco* paced a harbor-pilot craft and a U.S. Coast Guard patrol boat (both monohulls) without needing to slow down. A glass of water made the trip on a bridge shelf without sliding or spilling. In other trials, the builders have clocked speeds of 20 mph through four-to six-foot waves, with stability they estimate to equal that of a conventional single-hull design of several hundred feet.

Tim Kelley, a representative of Swath Ocean Systems, compares the *Chubasco's* ride to the glide of a submarine and reports that he's never seen the boat slam into or take green water over the bow.

*Chubasco* uses Swath concepts employed by the U.S. Navy's stable semi-submerged platform ship, *Kaimalino* ["Semi-Submerged Platform," Dec. '75]. Since 1973 the Navy has operated the Swath ship in the steep seas around the Hawaiian Islands. In side-by-side tests several years ago the 88-foot *Kaimalino* demonstrated better sea-keeping performance than a 375-foot Coast Guard cutter of conventional design. Both the *Kaimalino* and the *Chubasco* use a patented Swath design developed by Dr. Thomas G. Lang of Semi-Submerged Ship Corp.

### Above the waves

Cheoy Lee Shipyards in Hong Kong is producing in fiberglass another approach to level pleasure boating—a surface-effect ship (SES) design—from patented plans by Air Ride Craft of Miami, Fla.

Unlike a hovercraft, which scoots above water (or land) on a fan-maintained cushion of air that lifts up the complete vehicle, the semi-catamaran-type hull design encloses air in a 65-foot-long center tunnel formed by

side and stern walls. A flexible curtain of rubberized fabric at the bow keeps in the pressurized air. By keeping part of the hull in the water, the Cheoy Lee SES will avoid the hovercraft's tendency to slide sideways like a hockey puck.

The 87-foot Cheoy Lee SES yacht has a 300-horsepower blower to ram air at 80 to 100 pounds per square foot into the hull cavity, making the vessel rise two feet from its 5.5-foot at-rest draft when underway. When pressurized, the air chamber will support nearly 85 percent of the boat's 135,000-pound weight.

The air cushion's lifting action is intended to minimize the oscillations from wave motion and to boost speed and fuel economy by cutting wetted-surface drag from water friction.

Sensors in the tunnel chamber will feed information about the pressure peaks caused by passing waves to a microprocessor-based controller that vents excess air through a topside valve when required to help smooth out the ride.

Twice as fast as the *Chubasco*, the 50-knot SES speedster will get its maneuvering thrust from twin 1,300-hp General Motors diesels powering Arneson Drive surface-piercing propellers, which are like those used on some racing boats.

Cheoy Lee plans to build Air Ride yachts up to 100-plus feet, and a 102-foot commercial ferry that can carry as many as 350 passengers up to 40 knots.

### Other surface-effect ships

The Air Ride design is similar to that used on three 110-foot surface-effect ships that the Coast Guard operates on anti-drug smuggling patrols out of Key West, Fla. The high speed and low draft provided by the surface-effect hulls allows these craft to chase down drug-running speedboats in shallow coastal waters.

Avondale Shipyards in New Orleans is now building 109-by-34-foot aluminum ferries of Air Ride design. They are to be powered by twin 1,700-hp diesels driving KaMeWa water jets. The first ship will ferry 400 passengers to and from New York City's Kennedy Airport and Wall Street at 40 knots. Service is planned to start early this summer.

"We'll have a hull that will lift up to give us a draft of only about a foot and a half, as well as greatly reduced skin friction," says Fred Ardolino, the new owner-operator of the New York ferry service. "The result is a boat that carries a lot more weight at higher speed while using less fuel. It will be like riding a giant shock absorber." **P 3**



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# Cordless glue guns

[Continued from page 79]

backs. The gun accepts only 5/16-inch glue sticks—the standard size is 1/2 inch—because company designers foresaw their cordless gun gluing in hard-to-reach spots requiring smaller amounts of adhesive. Unlike the other five guns, the Ungar is thumb-fed. Ungar vice president of sales and marketing Richard Shivers reports that continuous thumb feeding should deliver enough hot melt for any task. Like the Parker, the Ungar has no base from which to recharge. It doesn't even have a bail. It does however have a wire loop for convenient hanging. And Ungar offers only one general-purpose-type glue stick to fit this gun.

Along with the new glue guns have come glue innovations, and different formulas are identified by different colors.

Thermogrip has introduced three hot-melt adhesives. Besides its Amber All-Purpose, Clear Craft & Hobby, and White Sealer Caulk sticks, the company now features Weatherstrip (a removable nonpermanent clear sealer for windows and doors), Slow Set (formulated for wood and other porous materials, it takes 90 seconds to set), and Color/Craft (available in red, brown, and green).

But the fount of hot-melt innovation is Black & Decker. The company has introduced color-coded glue sticks to make choosing the right glue for a specific project easy. Ten—count 'em ten—formulations, no less. There are five types: All purpose, wood/repair, fabric/leather, plastic/caulk, and ceramic, each in fast- and slow-dry varieties. Color stripes run the length of the sticks, indicating what material they will bond. Orange, for example, identifies the fabric/leather formulation. One color stripe equals fast dry (30 to 60 seconds), two mean slow (90 to 120 seconds). The B&D glue sticks are available in packs of six, boxes of 25 (four-inch), or a four-pack of 10-inch sticks.

I found that being able to control setup time on both big and small jobs and being able to select the best glue for various jobs cut out a lot of guesswork and saved time in the shop.

But what about all those partially used glue sticks as you switch from one formulation to another? For \$10 B&D offers a GlueSaver mold set—a small stand with four silicone mold sleeves. Just squirt the molds full of hot glue; when cooled, they peel back to yield new and near-perfect reshaped glue sticks.

### MANUFACTURERS OF CORDLESS GLUE GUNS

**Black & Decker**, Box 798, Hunt Valley MD 21030-0748;  
**Emhart Home Products Div. (Thermogrip)**, Box 13716, Reading PA 19612; **Loctite Corp.**, 4450 Cranwood Ct., Cleveland OH 44128; **Parker Group**, 10 Bearfoot Rd., Northboro MA 01532; **Stanley Tools**, 600 Myrtle St., New Britain CT 06050; **Ungar**, Box 6005, Compton CA 90224-6005

# Superglues

[Continued from page 83]

squeezed into a thin enough film to expose it adequately to the surface moisture it needs to catalyze."

## Pet projects

Although CAs will do just about any job other glues can handle, most often I find myself using them in unusual ways.

I use them almost daily in the home and shop for dozens of little odd jobs. The most common is tacking. A drop or two will tack a workpiece, a hinge, or a curtain-rod bracket in place so it can't skid out of position while I nail or screw it down. If work tends to slide around on my drill-press table, I tack it down.

To whip the end of a rope I soak it with glue and mist it with kicker. If I need to drive a screw in a tight or awkward spot, I tack the screw to the tip of my screwdriver so I can work one-handed. The photos and captions show more applications.

Bill Hunter has used CA as a wood finish on both his kitchen table and the walnut instrument panel of his Sunbeam Tiger. His technique? Dribble Hot Stuff (Satellite City's thin formula) on the wood, spread it around with a business card, then mist lightly with kicker. Sand lightly with fine paper on a block. Then repeat, applying two or three coats. You can get a matte finish by rubbing with steel wool, or use polishing compound to achieve a high gloss. A complete multi-coat job takes less than half a day.

Using CA with kicker opens up a realm of possibilities. You can lay a thick bead of the viscous stuff and spray kicker over it to create a neat fillet along a seam. By alternately applying glue and kicker you can build up acrylic plastic to any shape you like. A fishing fanatic, I use this technique to build plastic-bodied flies.

The only way you'll ever realize the full potential of CAs is to buy some and have them on hand. I'd suggest a bottle of the thin stuff, a bottle of one of the thickest formulations, and a spray bottle of kicker.

You aren't likely to run into one- or two-ounce bottles of CA in the local drugstore. I've seen these products in hobby shops (model makers love it), but I usually turn to mail-order catalogs aimed at model makers and woodworkers. If you have special needs or questions, or have trouble locating the adhesive you want, contact the manufacturers directly.

### SOME MANUFACTURERS OF SUPERGLUES

**Carl Goldberg Models**, 4734 W. Chicago Ave., Chicago IL 60651; **Loctite Corp.**, 4450 Cranwood Ct., Cleveland OH 44128; **Pacer Technology & Resources**, 1600 Dell Ave., Campbell CA 95008; **PIC**, 943 North Shoreline Blvd., Mountain View CA 94043; **Satellite City**, Box 836, Simi Valley CA 93062; **Sig Manufacturing Co. Inc.**, 41-7 S. Front St., Montezuma IA 50171; **3M Co.**, 3M Center, St. Paul MN 55144



## Gel stains

(Continued from page 84)

year of the gel stain, with the introduction of three new products: Behlen's Master Gel, Minwax's WoodSheen, and Fabulon's Gel-Eze.

The Master Gel and Gel-Eze lines contain separate stains and tung-oil-like top coats, both in thickened form. (Formby's, Flecto's, and Wood-Kote's are stains only.) WoodSheen, says Dorey Lum, Minwax group leader of research and development, is different. "It is a one-step wood-finishing product. Tung oil is mixed in with the stain so it colors and coats the wood at the same time [basically the same principle as the company's conventional-technology Polyshades]," says Lum. With that exception, however, all the products are similar: They are thick rather than watery, and they are applied by wiping onto wood with a cloth or fine (0000) steel wool. I traveled to the research center of Pratt & Lambert (parent company of Fabulon) in Buffalo, N.Y., to find out more about gel stains.

### Where it all starts

The enameled concrete floor shines under fluorescent lights as I look around me at lab tables, stacks of small birch panels used for color testing, and shelves upon shelves of plastic bottles with hand-lettered labels—resins, colorant dispersions, extenders like calcium carbonate, surfactants like lecithin, solvents, pigments: the stuff of wood-finish research.

Research and Development Group Leader Michael DePietro, a suave bearded gentleman with flecks of salt in his pepper-dark hair and whiskers, explains gel stains to me: "These stains basically contain the same ingredients that conventional stains do, but they have more pigment and vehicle, and therefore a higher solid content. And they contain a polyamide-modified thixotropic alkyd and other thixotropic agents that are mixed into the solution by a high-speed dispersion.

"Thixotropy can be described as false body. Through hydrogen bonding, the molecules in the solution form a soft gel structure. When you shake the solution, you break down the structure. The solution becomes fluid and easy to work with. When it sits, it settles back into a thick consistency. And when you apply shear forces to it, as when you rub it with a cloth, it spreads easily. A similar thixotropic technology is standard in water-based products like latex paint and enamel, and it is easy to 'build a puff' with them. It's much harder with oil-based solutions like these stains."

Paul Schlagter, a slightly rotund jolly technician with over 30 years' tenure at Pratt & Lambert, reaches under


one of the lab tables to pull out a cardboard box full of containers of various sizes and descriptions. "Actually, developing the formula wasn't all that difficult," he says as he hoists the box. "That took only a few months' work. It was designing the packaging that was difficult. That held up product development for about a year."

### Squeezing stain

"We thought we wanted a pressurized aerosol dispenser, similar to shaving cream, mousse, or whipped cream, but that gave us all kinds of problems," explains Schlagter. "Once, when I was testing one of the containers, I turned it upside down and pressed the nozzle. Nothing happened. I called my assistant, and as I did I held the can up at an angle. I guess I pressed the nozzle a little, because a wad of coagulated stain shot out of the can with a whoosh! It just missed his head and splattered on the wall. Well, we killed that idea in a hurry."

What Fabulon and other manufacturers settled on was a squeeze bottle made of polyethylene terephthalate (PET) or polyvinyl chloride (PVC) plastic. DePietro says that PET was chosen because, unlike some other kinds of plastic, it doesn't allow oxygen cross-over, which would quickly break down the stain. (X-30 and Gelled Wood Stain come in cans; the others, in squeeze bottles.)

Gel stains don't necessarily do a better job than conventional stains. In fact, says Minwax's Lum, "for large jobs such as staining big flat panels, conventional stains can be applied twice as fast." It is for the small job—staining a chair or small table with difficult-to-stain vertical and turned surfaces—that gel stains are intended. I found them easy to use with a cloth application, and because there is no settling, especially convenient as I didn't have to stir them every few minutes. The Wood Stain is creamier than the others, all of which are a bit more runny. Because wood doesn't absorb higher-solid-content stain as readily as it does conventional stain, color is easier to control, and you don't get any lapping. Color coverage and quality for all the products are excellent.

Gel stains certainly won't displace conventional wood-finishing stains, especially for those who do high-volume work. But if you just stain small pieces and you want to keep the mess to a minimum, they are hard to beat. 

#### MANUFACTURERS OF GEL STAINS

H. Behlen & Bros., Rte. 30 N., Amsterdam NY 12010; Fabulon Products, Box 1505, Buffalo NY 14240; The Flecto Co., 1000 45th St., Oakland CA 94608; Minwax Co., 102 Chestnut Ridge Plaza, Montvale NJ 07645; Thompson & Formby, Box 677, Olive Branch MS 38654; Wood-Kote, Box 17192, Portland OR 97217

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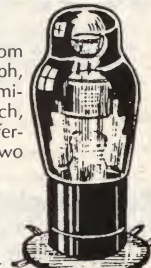
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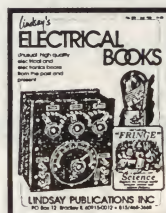


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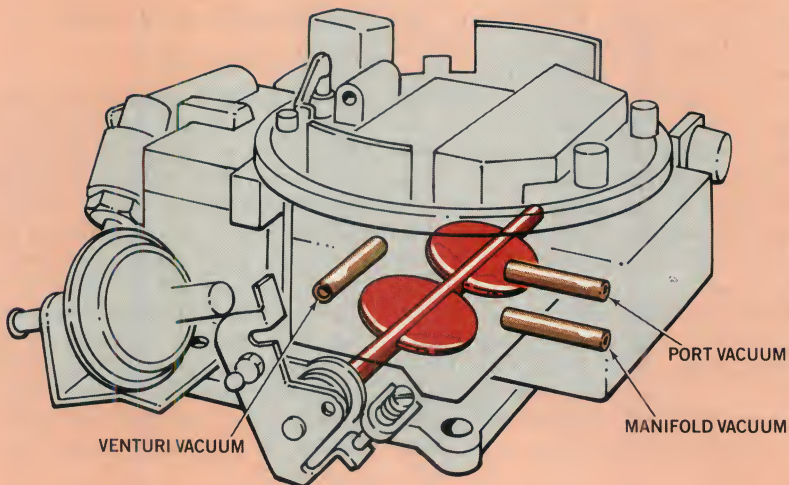
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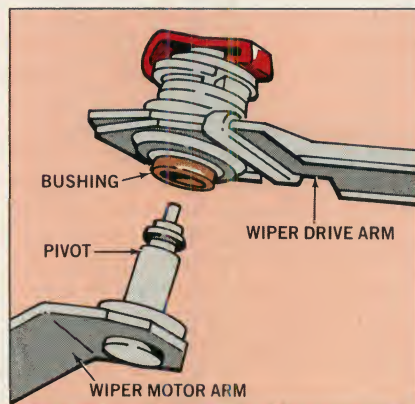
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## Vacuum savvy helps sort it all out

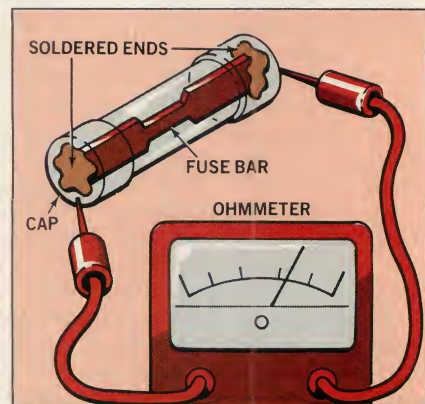
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the engine is at idle. Ported vacuum comes from just above the throttle blade and produces slightly less vacuum. Venturi vacuum comes from a port located near the carburetor's venturi and produces less than five inches of vacuum when the throttle plate is almost fully open.



## Wiper racket

A loud clunking noise coming from the windshield wipers often can be traced to a worn bushing between the wiper drive arm and motor arm. With the battery disconnected, manually move each wiper arm back and forth, looking for sloppiness or excessive play at the arm's elbow. Replace any worn or cracked parts.



## Solder stopper

An electrical fuse may appear to be in good condition but occasionally fail when the soldered joint that connects the fuse bar to the end caps has become separated or burned out and no longer makes contact. This type of failure is hidden from view and can be tested by checking the fuse for continuity with an ohmmeter.

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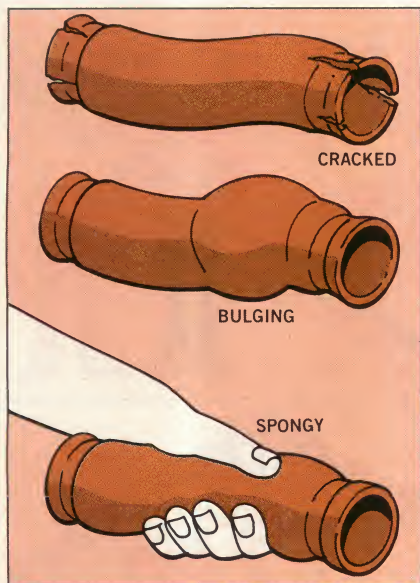
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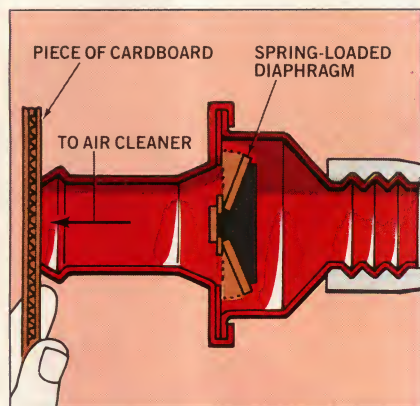
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## Hose check

Old radiator hoses are a common cause of cooling-system failure and should be inspected often. With the engine off and cold, look for hardened or cracked hoses, particularly near hose clamps. Any hoses that feel spongy should be replaced. Start the engine, and look for bulging.



## Aspiration check

Is there noise coming from under the hood? Check your engine's aspirator valve connected to the exhaust manifold. With the engine at idle speed and in neutral, hold a piece of cardboard over the aspirator valve. With a good valve you can feel vacuum exhaust pulses, but a defective valve will allow hot exhaust gases to escape.

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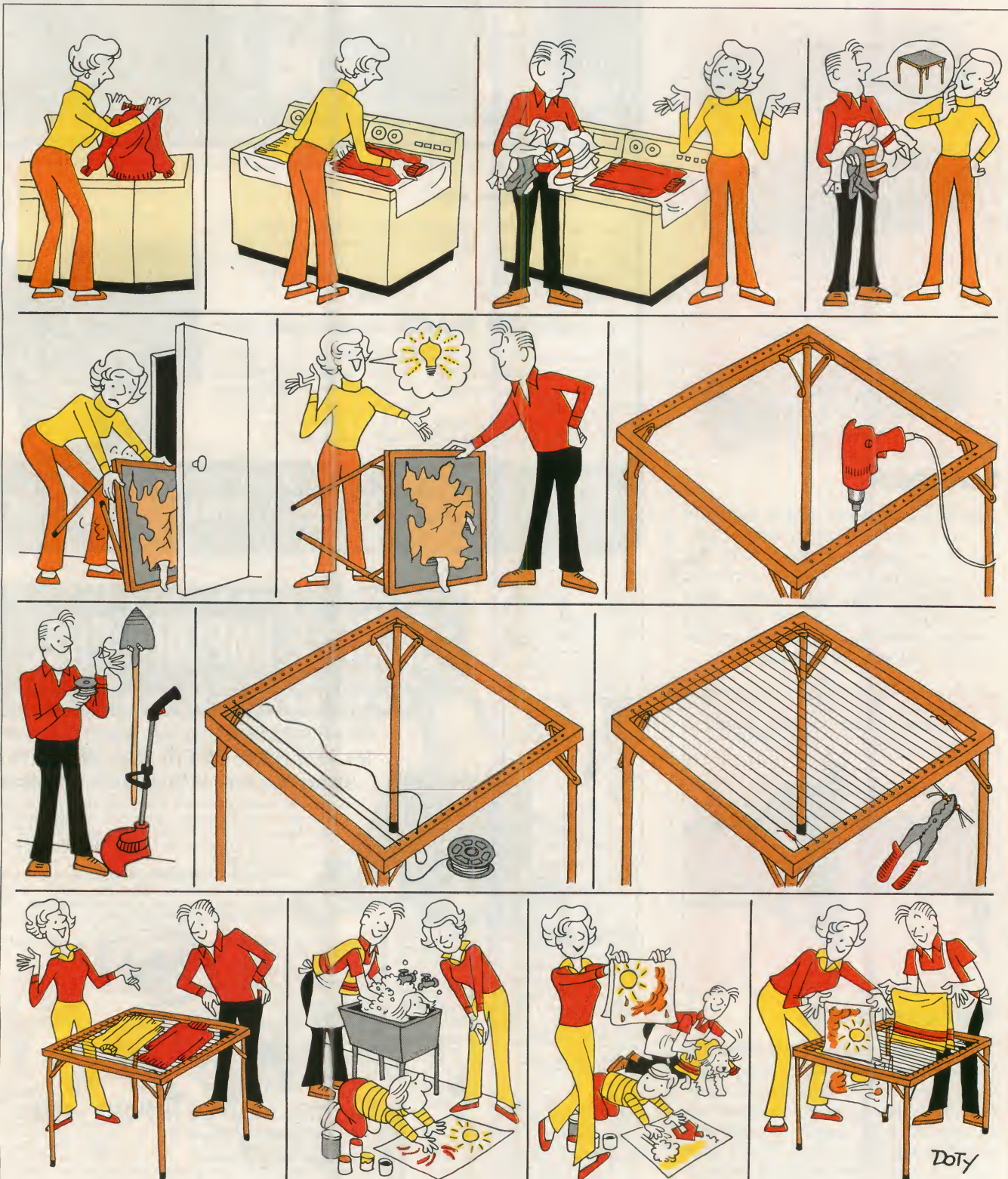
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## Brain-style computers

*(Continued from page 72)*

According to Scott E. Fahlman, a senior research scientist at Carnegie-Mellon University in Pittsburgh, Pa., "building a chip for just one network can take two or three years." The problem is that the process of laying out all the interconnected wires requires advanced techniques. Simulating networks on digital machines allows researchers to search for the best architecture before committing to hardware.

### Cheap imitation

"There are at least fifty different types of networks being explored in research or being developed for applications," says Hecht-Nielsen. "The differences are mainly in the learning laws implemented and the topology [detailed mapping] of the connections." Most of these networks are called "feed-forward" networks—information is passed forward in the layered network from inputs to hidden units and finally outputs.

John Hopfield is not sure this is the best architecture for neural nets. "In neurobiology there is an immense amount of feedback. You have connections coming back through the layers or interconnections within the layers. That makes the system much more powerful from a computational point of view."

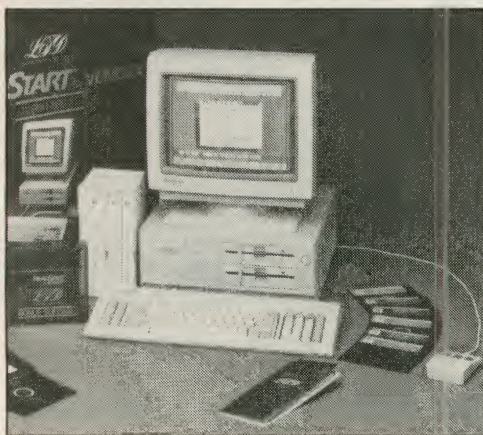
That kind of criticism brings up the question of how closely neural networks need to model the brain. Fahlman says that neural-network researchers and neurobiologists are "loosely coupled." "Neurobiologists can tell me that the right number of elements to think about is tens of billions. They can tell me that the right kind of interconnection is one thousand or ten thousand to each neuron. And they can tell me that there doesn't seem to be a lot of flow backward through a neuron," he says. But unfortunately, he adds, "they can't provide information about exactly what's going on in the synapse of the neuron."

Neural networks, according to the DARPA study, are a long way off from achieving the connectivity of the human brain; at this point a cockroach looks like a genius. DARPA projects that in five years the electronic "neurons" of a neural network could approach the complexity of a bee's nervous system. That kind of complexity would allow applications like stealth aircraft detection, battlefield surveillance, and target recognition using several sensor types. "Bees are pretty smart compared with smart weapons," commented Craig I. Fields, deputy director of research for the agency. "Bees can evade. Bees can choose routes and choose targets."

**P 3**

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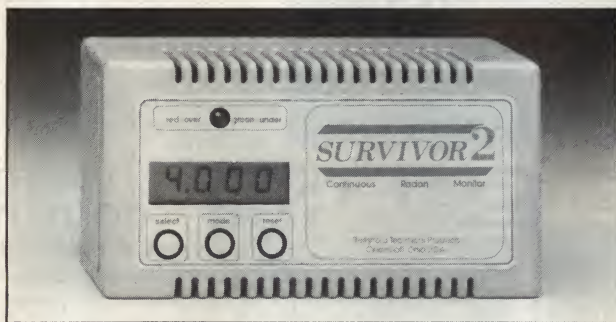
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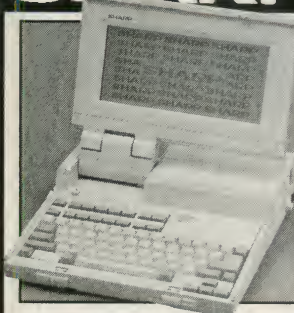
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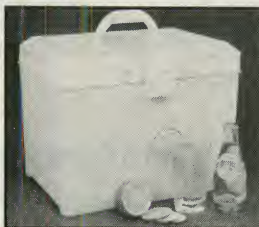
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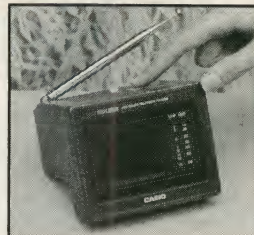
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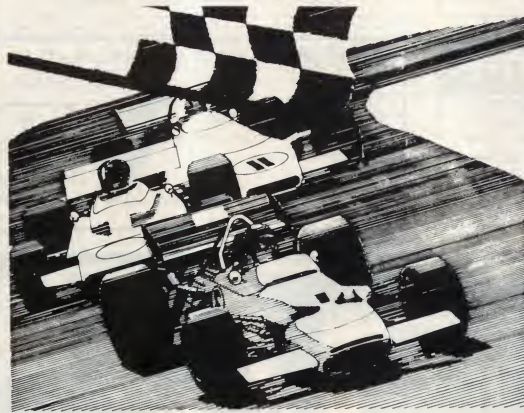
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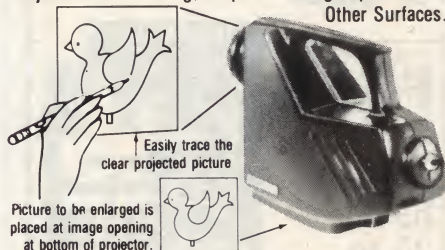
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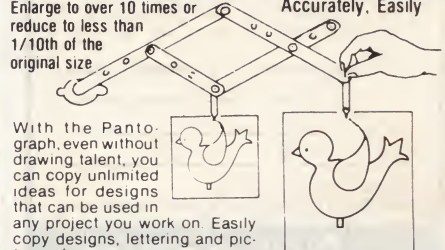


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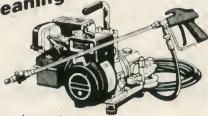


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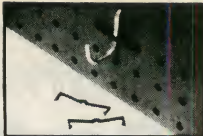
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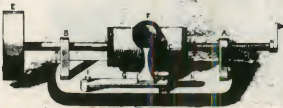
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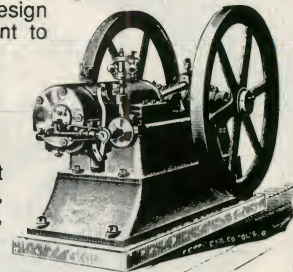
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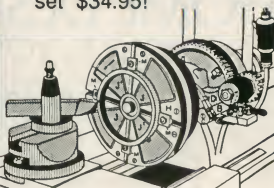
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Reached your breaking point? Wait! Don't throw expensive china. Give Stress Rock a toss or smack. On impact, it sounds like someone threw an entire tray of glasses against a wall. Feels sooooo good to do it over & over. Lights up, so safe. Requires standard battery. About 6".

662 Stress Rock ..... \$24.95

### Micro Wireless Mike

Picks up the slightest sounds & transmits them through your FM radio receiver with no wires. FCC-approved microphone operates up to 1000 yards on a single battery. Transmits within 88-108 MHz FM. Under ideal conditions it can transmit up to 300 ft. Only 2 1/2" x 1 1/2" & less than 1 oz. With flexible antenna, instructions & battery.

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### Pocket Electronic Mosquito Repeller

Superior Swiss designed miniature electronic device keeps biting insects 6 to 8 feet away. Emits special high pitched audio frequency sound that pests can't stand. Easily carried on belt, pocket, golf bag, etc. Only 4 1/4". Manufacturer claims it's more effective than any liquid repellent. Millions have been sold in the U.S. & Europe. Battery included.

Electronic Bug Shield ..... \$17.95

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Repel pests with sounds you can't hear. Throw away your poisons! Ultrasonic sprays. Small enough to fit in the palm of your hand. Vermex eliminates rats, mice & crawling bugs in 2500 sq. ft. area. Creates high-pitched ultrasonic sound waves that pests can't stand. Made in U.S. under American patent & EPA number. Plugs into wall outlet or requires 9-volt battery. 4 1/2" x 1 1/2" x 1 1/2".

6839 Vermex ..... \$39.95

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Answer your phone at any time without interference from your answering machine. No more talking over your outgoing message. Just pick up your receiver & Message Stopper automatically bypasses & resets your answering machine while you talk. Simply plug into modular jack & you're ready to go.

9713 Message Stopper ..... \$14.95

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3510 Smoke Golf Balls ..... \$8.95

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2983 Boomerang Plane ..... 2 for \$2.50

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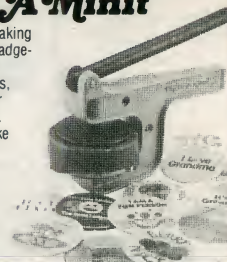
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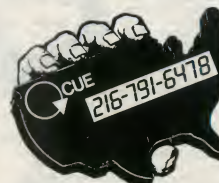


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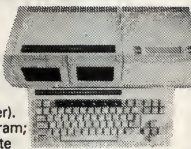
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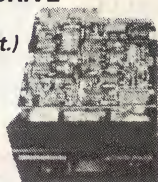
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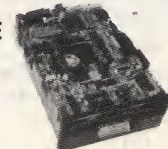
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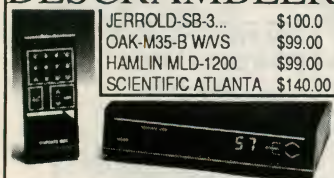
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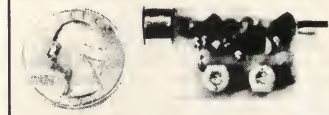
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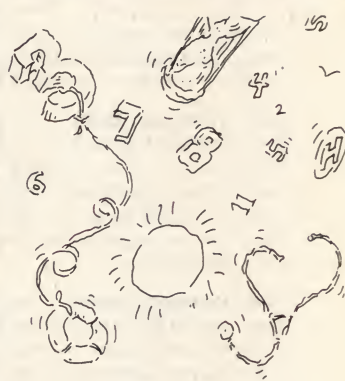
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